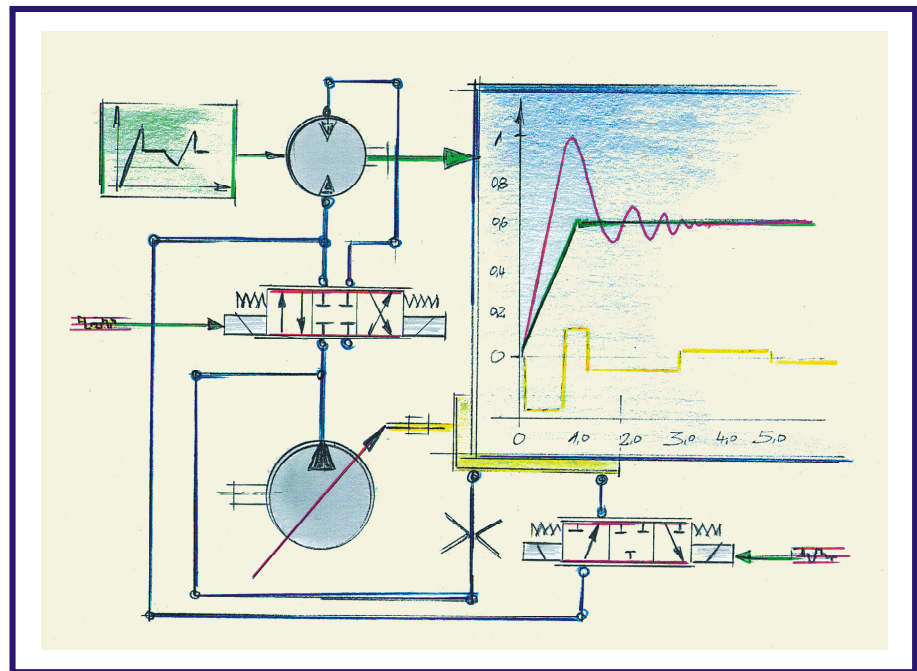


Component Manual

Pneumatics



DSH^{plus}

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In the course of further development of the software, parts of this manual can lose their validity.

Introduction

The component manual describes the components of the library. In accordance with the component categories in the library, the manual subdivides itself into several parts:

- Component library Hydraulics
- Component library Pneumatics
- Component library Control,
- Component library Mechanics
- Component library Thermal Hydraulics
- Component library Modules
- Component library Miscellaneous

The **HYDRAULICS** part contains all hydraulic components of the library. This includes pumps and motors, flow valves, pressure valves, check valves, and directional valves as well as accumulators and pipes.

The **PNEUMATICS** part of the library includes many components for pneumatic systems. The components range from cylinders and resistors to directional valves and sensors.

In the manual part **MECHANICS** the mechanical components are described. These are the masses and the spring damper components as well as other mechanical components.

The component library of *DSHplus* includes analog and digital components for control tasks that are explained in the chapter **CONTROL**.

The **THERMAL HYDRAULICS** part contains thermal hydraulic components of the library. This includes pumps and motors and directional valves as well as accumulators and pipes.

The component manual should help to select the right component for a model and to parameterize it. Furthermore, there is information about the kind of modeling of the components, e. g. whether they were modeled in accordance with the physical qualities of the real components or whether only their dynamic characteristics were taken.

The **MODULES** contains the components for the *DSHplus*-STC and for the sub model prepare. The part **MISCELLANEOUS** contains other components to which the nodes in particular belong.

All components are described according to the same scheme. The following page shows an example component with which the scheme is explained.

ComponentName

Symbol of the component

Symbol

Sketch

Drawing of the component

Connectors and Variables

Name	Type	Unit	Description
<i>Hydraulic connector</i>	Hydr	Unit	<i>short description</i>
<i>Hydraulic volume less connector</i>	Hvol	Unit	<i>short description</i>
<i>Thermal hydraulic connector</i>	THydr	Unit	<i>short description</i>
<i>Pneumatic connector</i>	Pneu	Unit	<i>short description</i>
<i>Signal input</i>	In		<i>short description</i>
<i>Signal output</i>	Out		<i>short description</i>
<i>Mechanical connector</i>	Mech		<i>short description</i>
<i>Internal variable</i>	V		<i>short description</i>

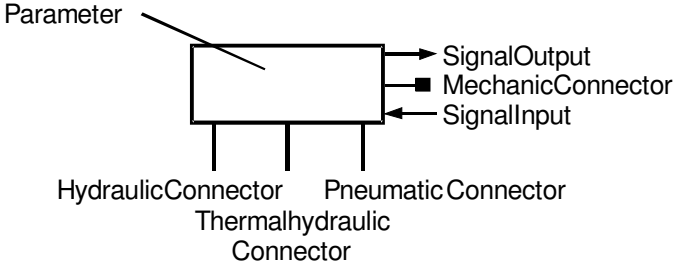
Parameters

Name	Value	Unit	Description
<i>Parameter name</i>	<i>Value</i>	<i>Unit</i>	<i>short description</i>

Notes

Remarks about function and application

Comments to the example component:

	The component symbol is the symbol with which a component appears in the library and in the model.														
	The component with its parameters and its connectors is represented in the component drawing according to the following figure:  The arrows at the component specify whether the connector is an input, an output or a mechanical connection. The direction of state variables is defined by a coordinate system.														
	In the table Connectors and Variables , all connectors and variables of a component are listed.														
	The connectors and variables of a component can be subdivided into different types. They are characterized in the column Type in accordance with: <table> <tbody> <tr> <td>Hydr:</td><td>hydraulic connector</td></tr> <tr> <td>Pneu:</td><td>pneumatic connector</td></tr> <tr> <td>Thydr:</td><td>thermal hydraulic connector</td></tr> <tr> <td>In:</td><td>input of a signal</td></tr> <tr> <td>Out:</td><td>output of a signal</td></tr> <tr> <td>Mech:</td><td>mechanical connector</td></tr> <tr> <td>V:</td><td>internal variable (state variable)</td></tr> </tbody> </table>	Hydr:	hydraulic connector	Pneu:	pneumatic connector	Thydr:	thermal hydraulic connector	In:	input of a signal	Out:	output of a signal	Mech:	mechanical connector	V:	internal variable (state variable)
Hydr:	hydraulic connector														
Pneu:	pneumatic connector														
Thydr:	thermal hydraulic connector														
In:	input of a signal														
Out:	output of a signal														
Mech:	mechanical connector														
V:	internal variable (state variable)														
	Units (column Unit) were assigned to the variables. In so far as the customer does not change the Units, the graphic or numeric edition of the variables occurs with these Units. The units for the values of the other connectors are listed only for better understanding.														
	In the parameter list, all parameters are listed with its Values and Units with which a component is described.														
	The Notes give further remarks to the function and the application of the component.														
	The following spelling is used: COMPONENTNAME <i>Parameters, Connectors and Variables</i>														

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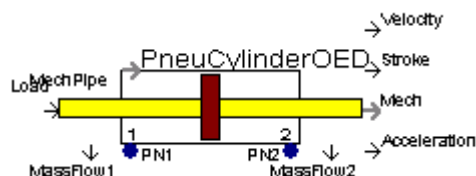
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Pneumatics

Motors

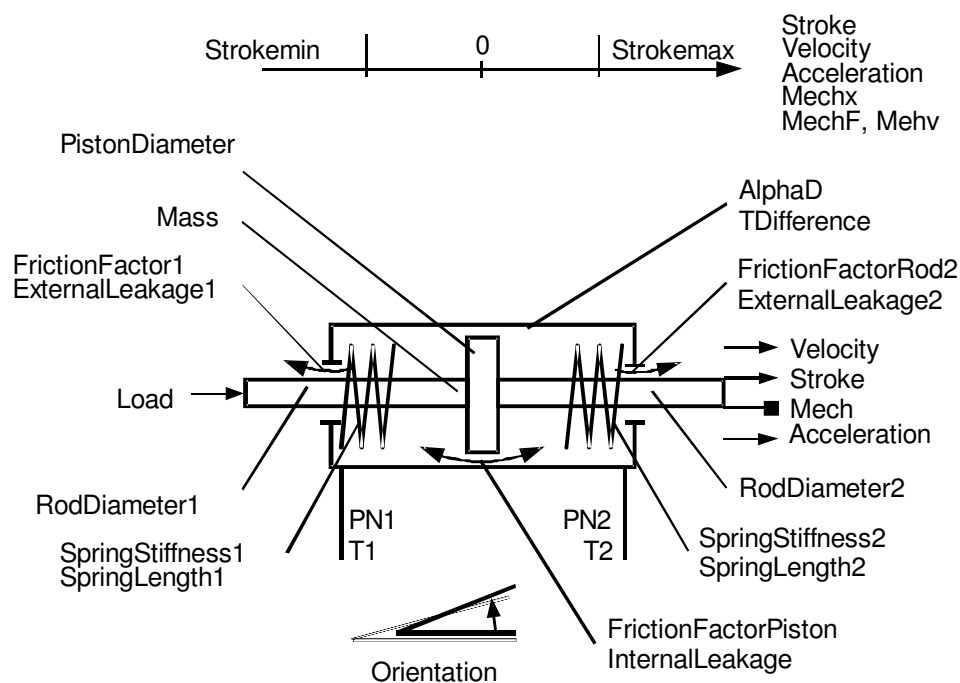
Linear Motors

PneuCylinderOED



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder

Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on
Mechx	Out	mm	the piston
Mechv	Out	m/s	stroke of the piston
			velocity of the piston
MechPipe	Mech	-	mechanical connector
MechF	Out	N	force which takes effect on
Mechx	In	mm	the cylinder housing
Mechv	In	m/s	Stroke of the cylinder
			housing
			velocity of the cylinder
			housing
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction
DeadStroke1	0	mm	length of the dead volume at the cylinder side 1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
Mass	1	Kg	mass of the piston and the cylinder rod
Orientation	0	deg	angle of the positive axis to the horizontal one
SpringStiffness1	0	N/mm	stiffness of the spring 1
SpringStiffness2	0	N/mm	stiffness of the spring 1
SpringLength1	50	mm	unstretched length of the spring 1
SpringLength2	50	mm	unstretched length of the spring 2
BreakawayForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MixedFrictionForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MixedFrictionLimit	0.001	m/s	characteristic value of the Stribeck-curve
MeasureFrictionForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MeasureFrictionVelocity	0.002	m/s	characteristic value of the Stribeck-curve
FrictionFactorRod1	0.1	1/bar	factor for the friction force at rod 1 in consideration of the pressure dependence of the Stribeck curve

FrictionFactorRod2	0.1	1/bar	factor for the friction force at rod 2 in consideration of the pressure dependence of the Stribeck-curve
FrictionFactorPiston	0.1	1/bar	factor for the friction force at the piston in consideration of the pressure dependence of the Stribeck-curve
Alpha	75	W/m ² /K	heat transfer number
PolytropicExponent	1.4	-	-
Tdifference	0	K	difference between the cylinder side temperature and the temperature of the environment
ExternalLeakage1	0.01	l/min/ bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0.01	l/min/ bar	pressure dependent leakage at the rod seal 2
InternalLeakage	0.01	l/min/ bar	pressure dependent leakage at the piston seal
AirMassConsideration	0	-	consideration of air mass in the dynamic system calculation (1=on ; 0=off)

Notes

The component PneuCylinderOED is a model of an Differential cylinder with out the final position damping.

The component has been modelled in such a way to represent the physical designing of a cylinder. Hence the physical characteristic value (Eg. Pistonmass or spring stiffness) of the component must be defined. The factor heat exchange with the environment also been considered.

The Length of the return spring in the tension free condition has been parameterised, so that the length can be adjusted to adopt for the pretensioning.

Spring1 comes in to picture, if

$$\text{Stroke} = \text{Strokemin} - \text{DeadStroke1} + \text{SpringLength1}$$

and Spring2 comes in to picture, if

$$\text{Stroke} = \text{Strokmax} + \text{DeadStroke2} - \text{springLength2}$$

Hence, care should be taken in assigning the value of DeadStroke as it is always positive.

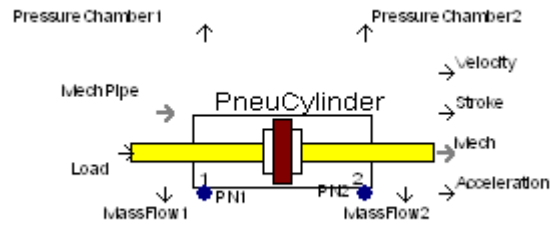
The frictional force of the pistonrod seal and the piston has been calculated based upon the streibeck friction curve. The frictional force values of the piston seal plotted over the velocity. The stribek curve has been generated for an pressure difference starting from 0 bar with the characteristic parameters BrakeawayfrictionforceperLength, MixedfrictionforceperLength, Mixedfriction, Measuring friction force per Length, and Measuring friction velocity.

The pressure dependent friction force over the parameter values (FrictionFactorRod1, Frictionfactorrod2 and FrictionFactorPiston) has been given by,

$$\begin{aligned} FrictionForce_{PressureDifference \neq 0} &= \\ &= FrictionForce_{PressureDifference = 0} \cdot (1 + |PressureDifference| \cdot Factor) \end{aligned}$$

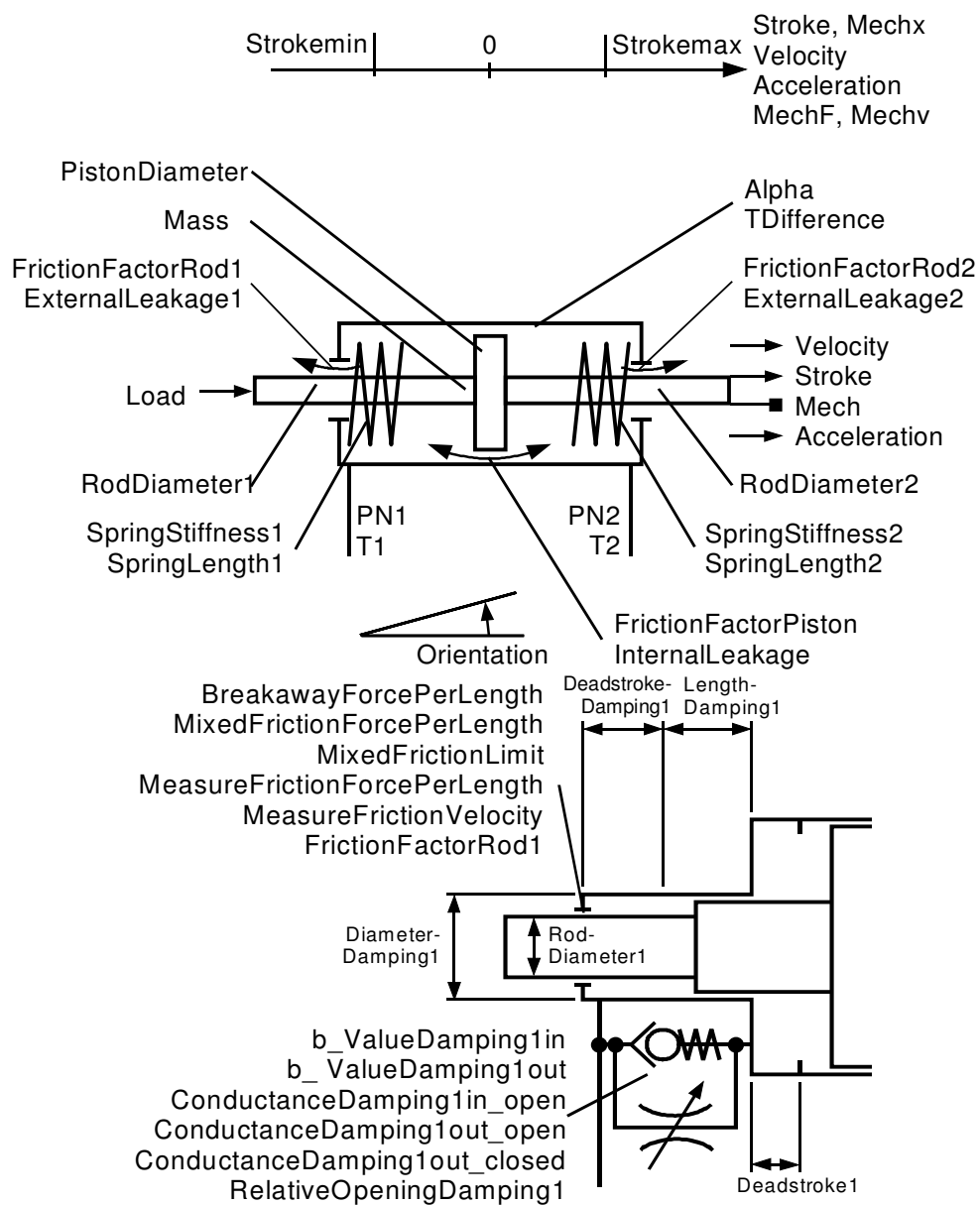
With the help of the parameter *AirMassConsideration* the influence of the air mass on the system behaviour could be taken into consideration. The weight force as well as the mass inertia of the relevant part of air, depending on cylinder orientation and piston position, are intergrated into the system calculation.

PneuCylinder



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
ChamberPressure1	V-Out	bar	pressure in the cylinder chamber 1
ChamberPressure2	V-Out	bar	pressure in the cylinder chamber 2
ChamberTemp1	V	K	temperature in the cylinder chamber 1
ChamberTemp2	V	K	temperature in the cylinder chamber 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MechPipe	Mech	-	mechanical connector
MechF	Out	N	force which takes effect on the cylinder housing
Mechx	In	mm	Stroke of the cylinder housing
Mechv	In	m/s	velocity of the cylinder housing
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction
DeadStroke1	0	mm	length of the dead volume at the cylinder side 1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
Mass	1	Kg	mass of the piston and the cylinder rod
Orientation	0	deg	angle of the positive axis to the horizontal one
SpringStiffness1	0	N/mm	stiffness of the spring 1
SpringStiffness2	0	N/mm	stiffness of the spring 2
SpringLength1	50	mm	unstretched length of the spring 1
SpringLength2	50	mm	unstretched length of the spring 2
Alpha	75	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
BreakawayForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MixedFrictionForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MixedFrictionLimit	0.001	m/s	characteristic value of the Stribeck-curve
MeasureFrictionForcePerLength	0	N/mm	characteristic value of the Stribeck-curve
MeasureFrictionVelocity	0.002	m/s	characteristic value of the Stribeck-curve

Name	Value	Unit	Description
FrictionFactorRod1	0.1	1/bar	factor for the friction force at rod 1 in consideration of the pressure dependence of the Stribeck curve
FrictionFactorRod2	0.1	1/bar	factor for the friction force at rod 2 in consideration of the pressure dependence of the Stribeck-curve
FrictionFactorPiston	0.1	1/bar	factor for the friction force at the piston in consideration of the pressure dependence of the Stribeck-curve
ExternalLeakage1	0.01	l/min/ bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0.01	l/min/ bar	pressure dependent leakage at the rod seal 2
InternalLeakage	0.01	l/min/ bar	pressure dependent leakage at the piston seal
EndPositionDamping1Activ	0	-	switch for end position damping 1 activ
EndPositionDamping2Activ	0	-	switch for end position damping 2 activ
DiameterDamping1	20	mm	diameter of the damping chamber 1
DiameterDamping2	20	mm	diameter of the damping chamber 2
LengthDamping1	20	mm	active length of the damping chamber 1
LengthDamping2	20	mm	active length of the damping chamber 2
DeadStrokeDamping1	0	mm	dead length of the damping chamber 1
DeadStrokeDamping2	0	mm	dead length of the damping chamber 2
b_ValueDamping1In	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from cylinder chamber 1 to the connector 1

Name	Value	Unit	Description
b_ValueDamping2In	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from cylinder chamber 2 to the connector 2
b_ValueDamping1Out	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from connector1 to the cylinder chamber 1
b_ValueDamping2Out	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from connector 2 to the cylinder chamber 2
ConductanceDamping1In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping2In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping1Out_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from connector 1 the to the cylinder chamber 1
ConductanceDamping2Out_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping1Out_closed	1	NI/s/bar	conductance of the damping 1 at closed throttle to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping2Out_closed	1	NI/s/bar	conductance of the damping 2 at closed throttle to a flow from the connector 2 to the cylinder chamber 2

Name	Value	Unit	Description
RelativeOpening-Damping1	50	%	relative opening of the damping throttle 1
RelativeOpening-Damping2	50	%	relative opening of the damping throttle 2
PolytropicExponent	1.4	-	polytropic exponent of the gas
AirMassConsideration	0	-	consideration of air mass in the dynamic system calculation (1=on ; 0=off)

Notes

The component PNEUCYLINDER is the model of a pneumatic synchronizing or differential cylinder, which could be provided with end position dampings on both sides.

The component is created in the same physical construction like a cylinder, so the physical characteristic values (e.g. piston mass or spring stiffness) have to be parametered. There is also a heat transfer with the environment, which has to take into account.

The length of the springs is parametered under unstretched condition, so the pretensioning can be adjusted.

Spring 1 works, if

$$Stroke = Strokemin - DeadStroke1 + SpringLength1,$$

and spring 2 works, if

$$Stroke = Strokemax + DeadStroke2 - SpringLength2.$$

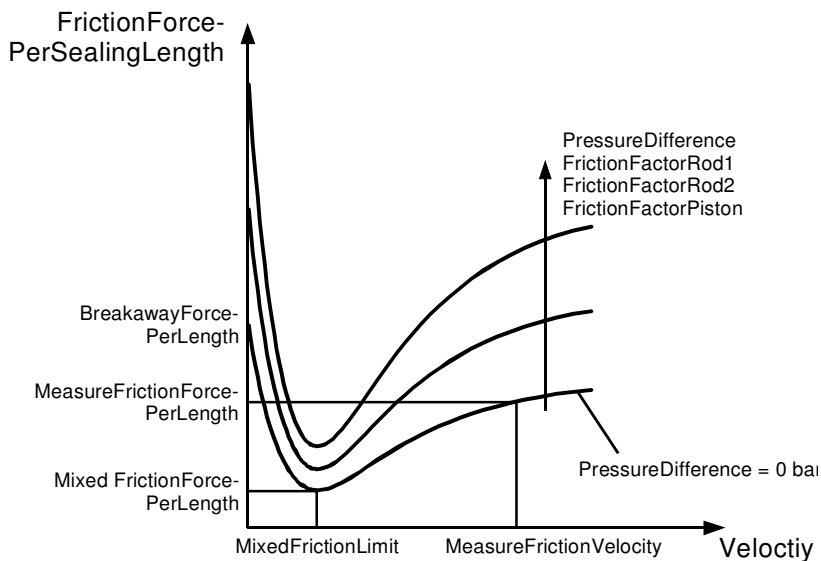
Pay attention the *DeadStroke* has to be positive every time.

The friction forces on the sealings of the piston rods and the piston are determined through the Stribeck-curves, in which the friction force referring to the sealing length is applied over the *velocity*. The Stribeck-curve is produced to a pressure difference from 0 bar with the characteristic values *BreakawayForcePerLength*, *MixedFrictionForcePerLength*, *MixedFrictionLimit*, as well as *MeasureFrictionForcePerLength* and *MeasureFrictionVelocity*.

The pressure dependence of the friction forces is computed by a several factor (*FrictionFactorRod1*, *FrictionFactorRod2* and *FrictionFactorPiston*):

$$\begin{aligned} \text{FrictionForce}_{\text{Pressure difference} \neq 0} &= \\ &= \text{FrictionForce}_{\text{Pressure difference} = 0} \cdot (1 + |\text{Pressure difference}| \cdot \text{Factor}) \end{aligned}$$

In the following figure the Stribeck-curve is described:



The cylinder has end position dampings on both sides, which are active, unless the parameters *EndPositionDampingActiv* and *EndPositionDamping2Activ* are composed to values unequal zero.

The end position damping becomes activated, unless the damping piston moves into the damping bush before reaching the *EndPosition* and the direct connection between the cylinder chamber and the extracted air is interrupted. While moving into the end position the air of the piston can only flow out through the throttle, therefore the piston movement is slowed down. During moving out of the *EndPosition* the air to flow unthrottled through the parallel check valve into the cylinder chamber, so there is hardly no delay.

The flow characteristics of the end position dampings are described by parameters through conductances, critical pressure ratios and the opening of the damping throttle.

If a differential cylinder should be modelled, only the rod diameter, has to be set to zero. To this cylinder side the external leakage automatically is set to zero. A differential cylinder could be represented with an own component symbol.

If the cylinder is in an inclined position the *Orientation* serves to consider the mass force.

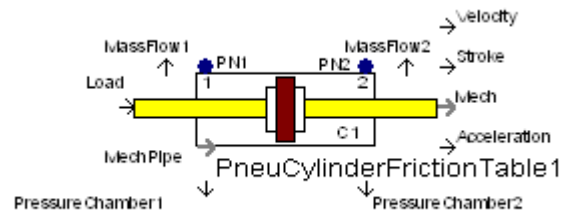
In the mechanical connector *Mech* of the component the variables *MechF*, the stroke *Mechx* and velocity *Mechv* are summarized.

With the mechanical connector *MechPipe* the cylinder can be attached to the environment. Because of the mass less cylinder housing in the model, an external mass has to be connected. This external mass again has to be attached with a spring to the environment.

A model of a pneumatic cylinder is even available as a component, for which flow characteristics of the dampings are described by characteristics through the conductance and the critical pressure ratios (PNEUCYLINDERKENN-FELD1, PNEUCYLINDERCHARACTERISTIC2).

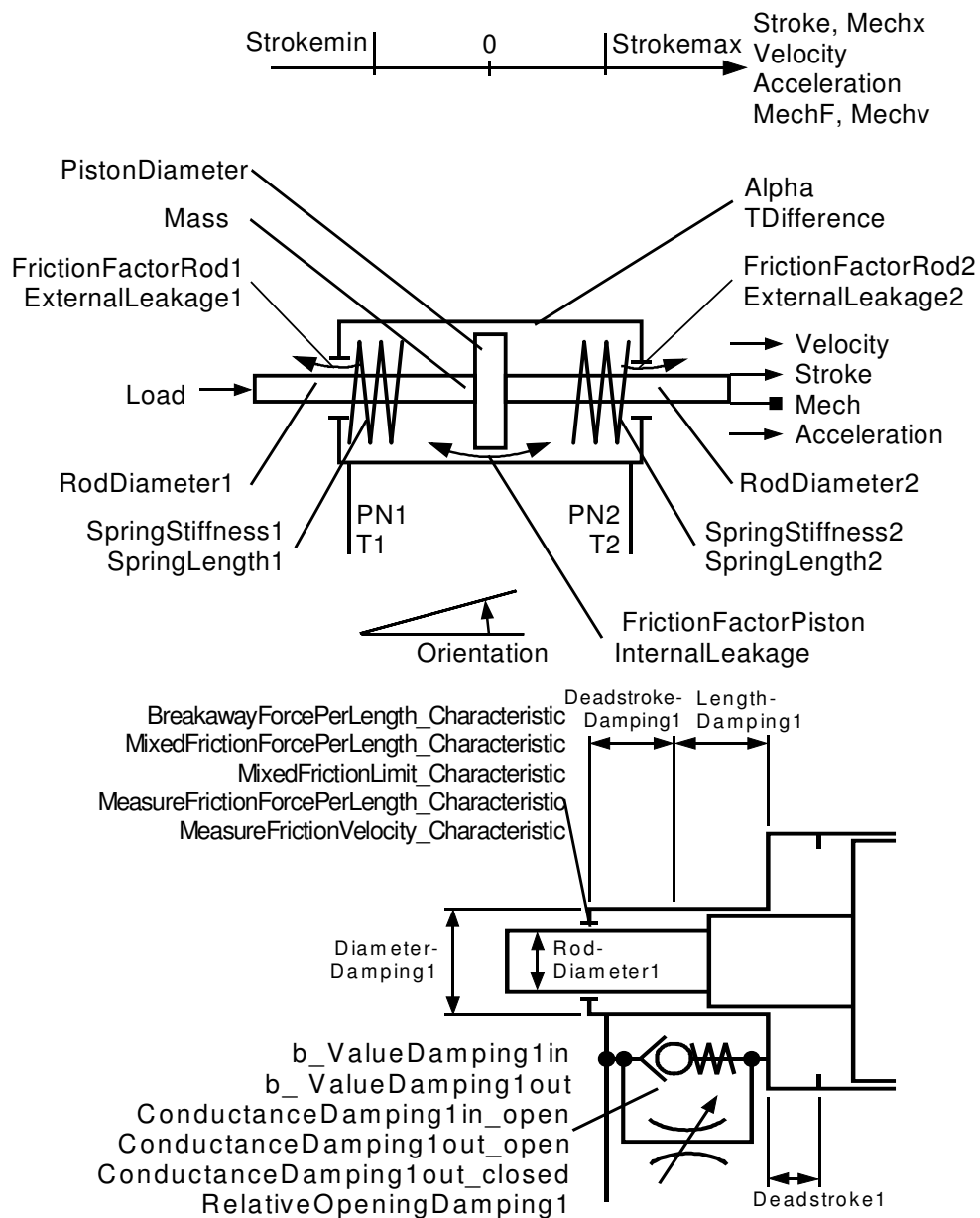
With the help of the parameter *AirMassConsideration* the influence of the air mass on the system behaviour could be taken into consideration. The weight force as well as the mass inertia of the relevant part of air, depending on cylinder orientation and piston position, are intergrated into the system calculation.

PneuCylinderFrictionTable1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
ChamberPressure1	V-Out	Bar	pressure in the cylinder chamber 1
ChamberPressure2	V-Out	Bar	pressure in the cylinder chamber 2
ChamberTemp1	V	K	temperature in the cylinder chamber 1
ChamberTemp2	V	K	temperature in the cylinder chamber 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MechPipe	Mech	-	mechanical connector
MechF	Out	N	force which takes effect on the cylinder housing
Mechx	In	mm	Stroke of the cylinder housing
Mechv	In	m/s	velocity of the cylinder housing
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction
DeadStroke1	0	mm	length of the dead volume at the cylinder side 1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
Mass	1	kg	mass of the piston and the cylinder rod
Orientation	0	deg	angle of the positive axis to the horizontal one
SpringStiffness1	0	N/mm	stiffness of the spring 1
SpringStiffness2	0	N/mm	stiffness of the spring 2
SpringLength1	50	mm	unstretched length of the spring 1
SpringLength2	50	mm	unstretched length of the spring 2
Alpha	75	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
ExternalLeakage1	0.01	l/min/bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0.01	l/min/bar	pressure dependent leakage at the rod seal 2
InternalLeakage	0.01	l/min/bar	pressure dependent leakage at the piston seal
EndPositionDamping1Activ	0	-	switch for end position damping 1 activ
EndPositionDamping2Activ	0	-	switch for end position damping 2 activ

Name	Value	Unit	Description
DiameterDamping1	20	mm	diameter of the damping chamber 1
DiameterDamping2	20	mm	diameter of the damping chamber 2
LengthDamping1	20	mm	activ length of the damping chamber 1 activ
LengthDamping2	20	mm	activ length of the damping chamber 2 activ
DeadStrokeDamping1	0	mm	dead length of the damping chamber 1
DeadStrokeDamping2	0	mm	dead length of the damping chamber 2
b_ValueDamping1In	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from cylinder chamber 1 to the connector 1
b_ValueDamping2In	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from cylinder chamber 2 to the connector 2
b_ValueDamping1Out	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from connector 1 to the cylinder chamber 1
b_ValueDamping2Out	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from connector 2 to the cylinder chamber 2
ConductanceDamping1In_o pen	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping2In_o pen	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1

Name	Value	Unit	Description
ConductanceDamping1Out_ open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from connector 1 the to the cylinder chamber 1
ConductanceDamping2Out_ open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping1Out_ closed	1	NI/s/bar	conductance of the damping 1 at closed throttle to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping2Out_ closed	1	NI/s/bar	conductance of the damping 2 at closed throttle to a flow from the connector 2 to the cylinder chamber 2
RelativeOpening-Damping1	50	%	relative opening of the damping throttle 1
RelativeOpening-Damping2	50	%	relative opening of the damping throttle 2
PolytropicExponent	1.4	-	PolytropicExponent of the gas
BreakawayForcePerLength_ Characteristic	-1	-	shows a characteristic value of the Stribeck-curve depending on the difference pressure on the sealing
MixedFrictionForcePerLength_ _Characteristic	-1	-	shows a characteristic value of the Stribeck-curve depending on the difference pressure on the sealing
MixedFrictionLimit_ Characteristic	-1	-	shows a characteristic value of the Stribeck-curve depending on the difference pressure on the sealing

Name	Value	Unit	Description
MeasureFrictionForcePerLength_Characteristic	-1	-	shows a characteristic value of the Stribeck-curve depending on the difference pressure on the sealing
MeasureFrictionVelocity_Characteristic	-1	-	shows a characteristic value of the Stribeck-curve depending on the difference pressure on the sealing

Notes

The component PNEUCYLINDERFRICTIONTABLE1 is a model of a pneumatic synchronizing or differential cylinder, at which the friction forces of the piston and the rod sealings are calculated through a Stribeck-curve. The characteristic values of this Stribeck-curve are described by characteristics depending on pressure.

The component is created in the same physical construction like a cylinder, so the physical characteristic values (e.g. piston mass or spring stiffness) have to be parametered. There is also a heat transfer with the environment, which has to take into account.

The length of the springs is parametered under unstretched condition, so the pretensioning can be adjusted.

Spring 1 works, if

$$Stroke = Strokemin - DeadStroke1 + SpringLength1 ,$$

and spring 2 works, if

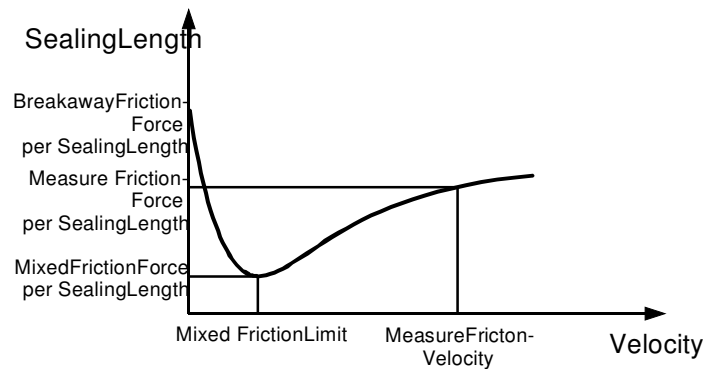
$$Stroke = Strokemax + DeadStroke2 - SpringLength2 .$$

Pay attention the *DeadStroke* has to be positive every time.

The friction forces on the sealings of the piston rods and the piston are determined through the Stribeck-curves, in which the friction force referring to the sealing length is applied over the *velocity*.. The characteristic values which produce the Stribeck-curves are calculated on the characteristics *BreakawayForcePerLength_Characteristic*, *MixedFrictionForcePerLength_Characteristic*, *MixedFrictionLimit_Characteristic*, as well as *MeasureFrictionForcePerLength_Characteristic* and *MeasureFrictionVelocity_Characteristic* depending on the pressure differences, which are enclosed to the sealings.

Im folgenden Bild ist als Beispiel eine Stribeck-Kurve mit aus den Kennfeldern erzeugten Kennwerten dargestellt.

In the following figure shows an example Stribeck-curve with characteristic values produced on the characteristics:



The cylinder has EndPosition dampings on both sides, which are active, unless the parameters *EndPositionDamping1Activ* and *EndPositionDamping2Activ* are set to zero.

The EndPosition damping becomes activated, when the damping piston moves into the damping bush before reaching the EndPosition and the direct connection between the cylinder chamber and the extracted air is interrupted. While moving the piston to the endposition the air can only flow out through the throttle, therefore the piston movement is slowed down. During moving out of the EndPosition the air is able to flow unthrottled through the parallel check valve into the cylinder chamber, so there is hardly no delay.

The flow characteristics of the end position dampings are described by parameters through conductance values, the critical pressure ratios and the opening of the damping throttle.

If a differential cylinder should be modelled, only the rod diameter, has to be set to zero. To this cylinder side the external leakage automatically is set to zero. A differential cylinder could be represented with an own component symbol .

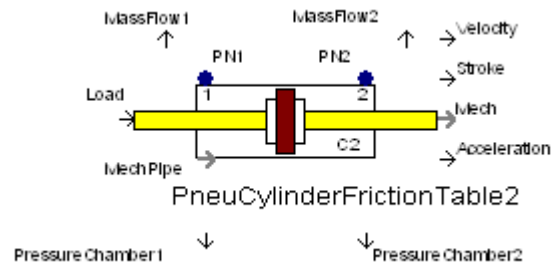
If the cylinder is in an inclined position the *Orientation* serves to consider the mass force.

In the mechanical connector *Mech* of the component the stroke of the cylinders (*Mechx*), the velocity (*Mechv*) and the load (*MechF*) are summarized.

With the mechanical connector *MechPipe* the cylinder can be attached to the environment. Because of the mass less cylinder housing in the model, an external mass has to be connected. This external mass again has to be attached with a spring to the environment.

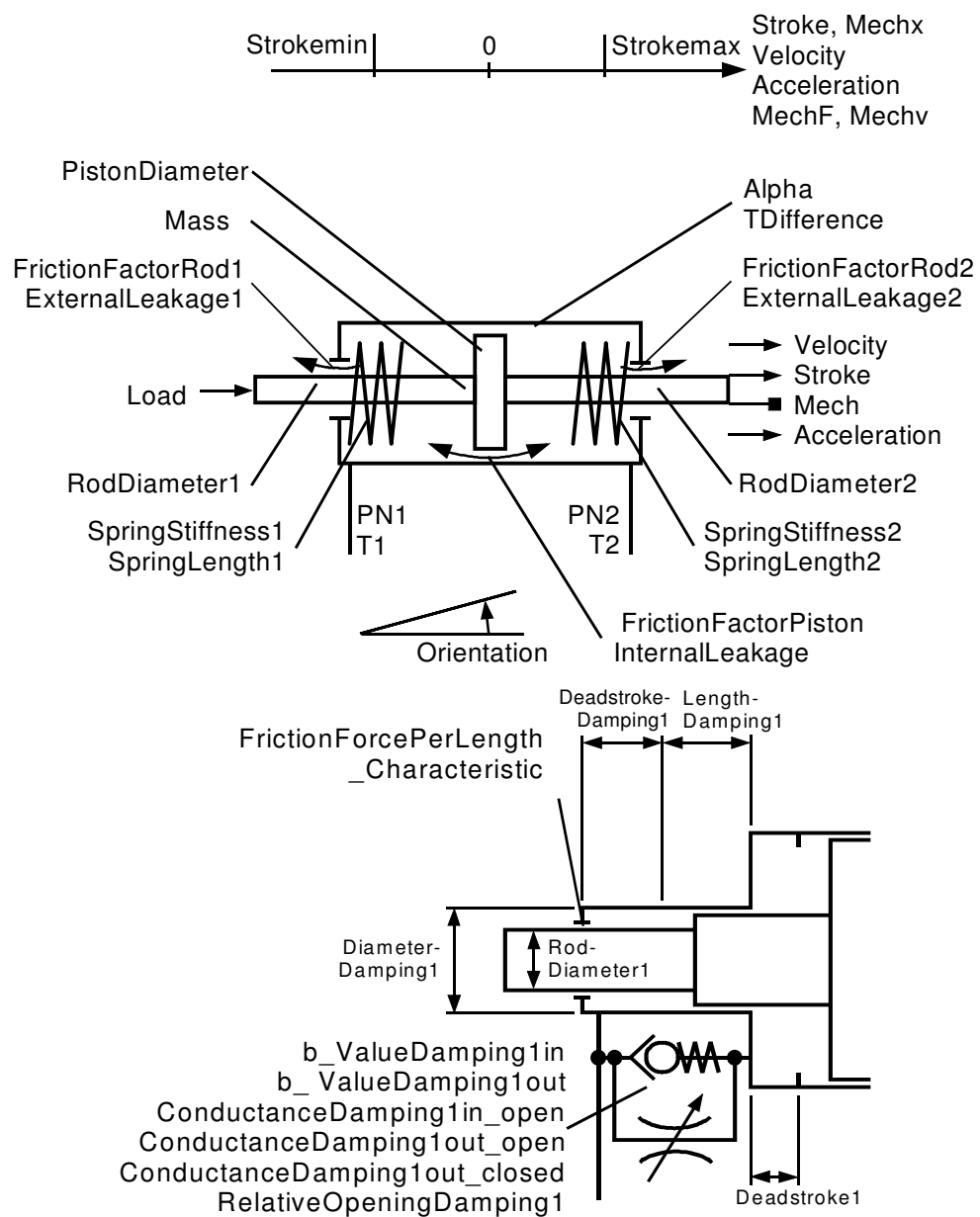
A model of a pneumatic cylinder is even available as a component, whichs friction forces of the sealings are calculated through a difference pressure dependent Stribeck-curve, which characteristic values are parameters. (PNEUCYLINDER). In the component PNEUCYLINDERCHARACTERISTIC2 the friction forces are determined through a two dimensional characteristic. In this characteristic the friction force referring to the length of a sealing is discarded depending on the pressure difference and the velocity.

PneuCylinderFrictionTable2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
ChamberPressure1	V-Out	bar	pressure in the cylinder chamber 1
ChamberPressure2	V-Out	bar	pressure in the cylinder chamber 2
ChamberTemp1	V	K	temperature in the cylinder chamber 1
ChamberTemp2	V	K	temperature in the cylinder chamber 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MechPipe	Mech	-	mechanical connector
MechF	Out	N	force which takes effect on the cylinder housing
Mechx	In	mm	Stroke of the cylinder housing
Mechv	In	m/s	velocity of the cylinder housing
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston

Name	Value	Unit	Description
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction
DeadStroke1	0	mm	length of the dead volume at the cylinder side1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
Mass	1	kg	mass of the piston and the cylinder rod
Orientation	0	deg	angle of the positive axis to the horizontal one
SpringStiffness1	0	N/mm	stiffness of the spring 1
SpringStiffness2	0	N/mm	stiffness of the spring 2
SpringLength1	50	mm	unstretched length of the spring 1
SpringLength2	50	mm	unstretched length of the spring 2
Alpha	75	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
ExternalLeakage1	0.01	NI/min/ bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0.01	NI/min/ bar	pressure dependent leakage at the rod seal 2
InternalLeakage	0.01	NI/min/ bar	pressure dependent leakage at the piston seal
EndPositionDamping1Activ	0	-	switch for end position damping 1 activ
EndPositionDamping2 Activ	0	-	switch for end position damping 2 activ
DiameterDamping1	20	mm	diameter of the damping chamber 1
DiameterDamping2	20	mm	diameter of the damping chamber 2

Name	Value	Unit	Description
LengthDamping1	20	mm	active length of the damping chamber 1
LengthDamping2	20	mm	active length of the damping chamber 2
DeadStrokeDamping1	0	mm	dead length of the damping chamber 1
DeadStrokeDamping2	0	mm	dead length of the damping chamber 2
b_ValueDamping1In	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from cylinder chamber 1 to the connector 1
b_ValueDamping2In	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from cylinder chamber 2 to the connector 2
b_ValueDamping1Out	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from connector1 to the cylinder chamber 1
b_ValueDamping2Out	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from connector 2 to the cylinder chamber 2
ConductanceDamping1In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping2In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping1Out_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from connector 1 to the cylinder chamber 1

Name	Value	Unit	Description
ConductanceDamping2Out_ open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping1Out_ closed	1	NI/s/bar	conductance of the damping 1 at closed throttle to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping2Out_ closed	1	NI/s/bar	conductance of the damping 2 at closed throttle to a flow from the connector 2 to the cylinder chamber 2
RelativeOpening-Damping1	50	%	relative opening of the damping throttle 1
RelativeOpening-Damping2	50	%	relative opening of the damping throttle 2
PolytropicExponent	1.4	-	PolytropicExponent of the gas
FrictionForcePerLength_ Characteristic	-1	-	shows the friction force on a sealing depending on the difference pressure on the sealings and the velocity

Notes

The component PNEUCYLINDERFRICTIONTABLE2 is a model of a pneumatic synchronizing or differential cylinder, at which the friction forces of the piston and the rod sealings are calculated through a Stribeck-curve. The characteristic values of this Stribeck-curve are described by characteristics depending on pressure.

The component is created in the same physical construction like a cylinder, so the physical characteristic values (e.g. piston mass or spring stiffness) have to be parametered. There is also a heat transfer with the environment.

The length of the springs is parametered under condition, so the pre-tensioning can be adjusted.

Spring 1 works, if

$$Stroke = Strokemin - DeadStroke1 + SpringLength1 ,$$

and spring 2 works, if

$$Stroke = Strokemax + DeadStroke2 - SpringLength2 .$$

Pay attention the *DeadStroke* has to be positive every time.

If a differential cylinder should be modelled, only the rod diameter, has to be set to zero. To this cylinder side the external leakage automatically is set to zero. A differential cylinder could be represented with an own component symbol.

The friction forces of the piston and rod sealings are determined through a two dimensional characteristic. In this characteristic the friction force considered to the length of a sealing is discarded depending on the pressure difference (*Input1* of the characteristic) and the velocity(*Input2* of the characteristic).

The cylinder has end position dampings on both sides, which are active, unless the parameters *EndPositionDamping1Activ* and *EndPositionDamping2Activ* are set to zero.

The end position damping becomes activated, when the damping piston moves into the damping bush before reaching the end position and the direct connection between the cylinder chamber and the extracted air is interrupted. While moving into the end position the air of the piston can only flow out through the throttle, therefore the piston movement is slowed down. During moving out of the end position the air is able to flow unthrottled through the parallel check valve into the cylinder chamber, so there is hardly no delay.

The flow characteristics of the end position dampings are described by parameters through conductance values, the critical pressure ratios and the opening of the damping throttle.

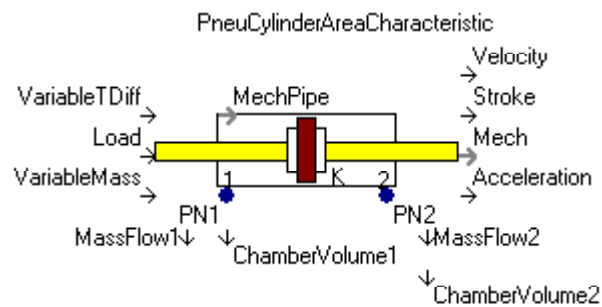
If the cylinder is in an inclined position the *Orientation* serves to consider the mass force.

In the mechanical connector *Mech* of the component the stroke of the cylinders (*Mechx*), the velocity (*Mechv*) and the load (*MechF*) are summarized.

With the mechanical connector *MechPipe* the cylinder can be attached to the environment. Because of the mass less cylinder housing in the model, an external mass has to be connected. This external mass again has to be attached with a spring to the environment.

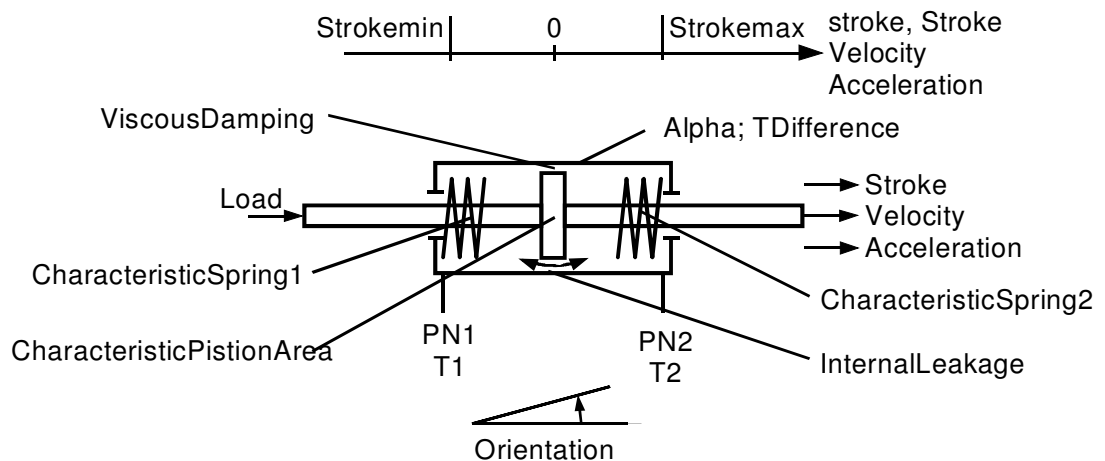
A model of a pneumatic cylinder is even available as a component, whichs friction forces of the sealings are calculated through a difference pressure dependent Stribeck-curve, which characteristic values are parameters (PNEUCYLINDER) or determined out of characteristics depending on the pressure difference(PNEUCYLINDERFRICTIONTABLE1).

PneuCylinderAreaCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
Acceleration	Out	m/s ²	acceleration of the piston
Velocity	V-Out	m/s	velocity of the piston
Stroke	V-Out	mm	stroke of the piston
Load	In	N	load which takes effect on the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MechPipe	Mech	-	mechanical connector
MechF	Out	N	force which takes effect on the cylinder housing
Mechx	In	mm	stroke of the cylinder housing
Mechv	In	m/s	velocity of the cylinder housing
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2
ChamberVolume1	Out	cm ³	actual volume of chamber 1
ChamberVolume2	Out	cm ³	actual volume of chamber 2
VariablTDiff	In	K	variable offset to the environment temperature
VariablMass	In	kg	variable offset to the piston mass

Parameters

Name	Value	Unit	Description
VolumeResolution	1.	mm	resolution of discrete volume units
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction

Name	Value	Unit	Description
Mass	1.	kg	mass of the piston and the cylinder rod
Orientation	0	deg	angle of the positive axis to the horizontal one
Alpha	75.	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
ViscousDamping	1.	Ns/m	
InternalLeakage	0.01	l/min/ bar	pressure dependent leakage at the piston seal
CharacteristicPistonArea	-1.	-	characteristic of the stroke dependent piston areas
Characteristicspring1	-1.	-	stroke dependent spring force in chamber 1
Characteristicspring2	-1.	-	stroke dependent spring force in chamber 2

Notes

The component **PNEUCYLINDERAERACHARACTERISTIC** is a model of a pneumatic synchronizing cylinder, which has two pneumatic ports. The variable piston area realizes arbitrary cylinder geometries, like e.g. plastic coatings.

The area of the piston is determined through the characteristic *CharacteristicPistonArea*, which has to be defined between the values *Strokemin* and *Strokemax*, depending on stroke.

To increase the calculation velocity the stroke dependent volume of both cylinder chambers is calculated before the simulation and selected to the running time. The parameter *VolumeResolution* defines with which stroke dependent resolution the volume values are calculated.

The velocity dependent friction between the piston and the cylinder side is computed under the parameter *ViscousDamping*. The friction force depends on pressure.

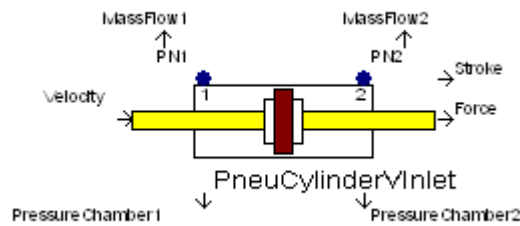
Springs could be deposited for each cylinder chamber in the form of a stroke dependent spring force characteristic. (parameters *CharacteristicSpring1* and *CharacteristicSpring2*). So even non linear spring force progressions like e.g. plastic coatings can be represented.

If the cylinder is in an inclined position the *Orientation* serves to consider the mass force.

In the mechanical connector *Mech* of the component the stroke of the cylinders (*Mechx*), the velocity (*Mechv*) and the load (*MechF*) are summarized.

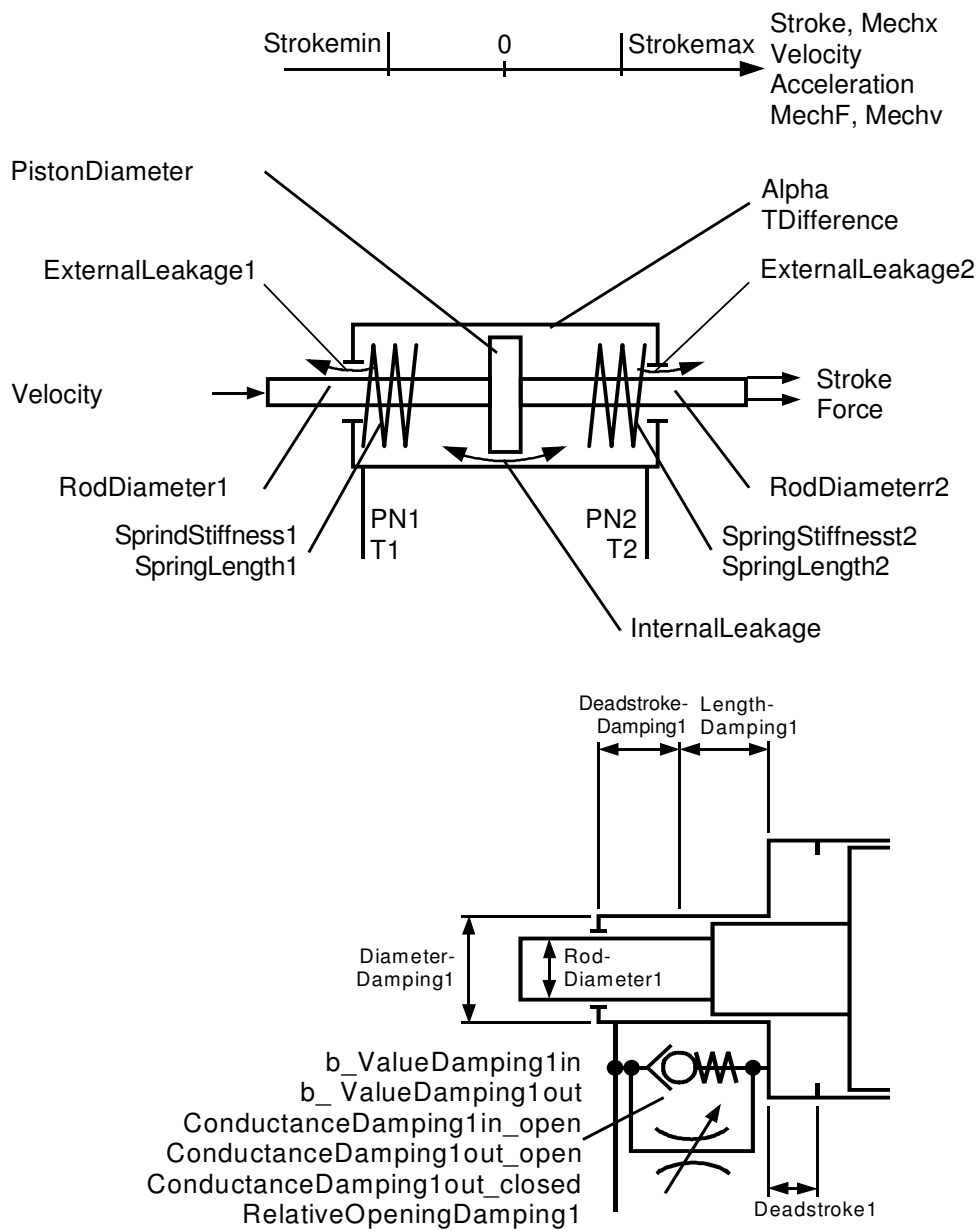
With the mechanical connector *MechPipe* the cylinder can be attached to the environment. Because of the mass less cylinder housing in the model, an external mass has to be connected. This external mass again has to be attached with a spring to the environment.

PneuCylinderVInlet



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
ChamberPressure1	V-Out	bar	pressure in the cylinder chamber 1
ChamberPressure2	V-Out	bar	pressure in the cylinder chamber 2
ChamberTemp1	V	K	temperature in the cylinder chamber 1
ChamberTemp2	V	K	temperature in the cylinder chamber 2
Velocity	In	m/s	velocity of the piston
Stroke	V – Out	mm	stroke of the piston
Force	Out	N	force which is delivered from the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction
DeadStroke1	0	mm	length of the dead volume at the cylinder side 1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
Mass	0	N/mm	mass of the piston and the cylinder rod
Orientation	0	N/mm	angle of the positive axis to the horizontal one
SpringStiffness1	50	mm	stiffness of the spring 1
SpringStiffness2	50	mm	stiffness of the spring 2
SpringLength1	75	W/m ² /K	unstretched length of the spring 1
SpringLength2	0	K	unstretched length of the spring 2
Alpha	0	N/mm	heat transfer number
TDifference	0	N/mm	difference between the cylinder side temperature and the temperature of the environment
ExternalLeakage1	0.01	NI/min/ bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0	-	pressure dependent leakage at the rod seal 2
InternalLeakage	0	-	pressure dependent leakage at the piston seal
EndPositionDamping1Activ	20	mm	switch for end position damping at cylinder side 1 activ

Name	Value	Unit	Description
EndPositionDamping2Activ	20	mm	switch for end position damping at cylinder side 2 activ
DiameterDamping1	20	mm	diameter of the damping chamber 1
DiameterDamping2	20	mm	diameter of the damping chamber 2
LengthDamping1	0	mm	active length of the damping chamber 1
LengthDamping2	0	mm	active length of the damping chamber 2
DeadStrokeDamping1	0.528	-	dead length of the damping chamber 1
DeadStrokeDamping2	0.528	-	dead length of the damping chamber 2
b_ValueDamping1In	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from cylinder chamber 1 to the connector 1
b_ValueDamping2In	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from cylinder chamber 2 to the connector 2
b_ValueDamping1Out	1	NI/s/bar	critical pressure ratio of a flow through the damping 1 to the flow direction from connector1 to the cylinder chamber 1
b_ValueDamping2Out	1	NI/s/bar	critical pressure ratio of a flow through the damping 2 to the flow direction from connector 2 to the cylinder chamber 2
ConductanceDamping1In_o pen	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1

Name	Value	Unit	Description
ConductanceDamping2In_o pen	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping1Out_ open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from connector 1 the to the cylinder chamber 1
ConductanceDamping2Out_ open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping1Out_ closed	50	%	conductance of the damping 1 at closed throttle to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping2Out_ closed	50	%	conductance of the damping 2 at closed throttle to a flow from the connector 2 to the cylinder chamber 2
RelativeOpening-Damping1	50	%	relative opening of the damping throttle 1
RelativeOpening-Damping2	50	%	relative opening of the damping throttle 2
PolytropicExponent	1.4	-	polytropic exponent of the gas

Notes

The component PNEUCYLINDERVINLET is a model of a synchronizing or differential cylinder, which could be has an end position damping on both sides. The piston velocity is an output value. The force, generating the cylinder, is caculated.

The component is created in the same physical construction like a cylinder, so the physical characteristic values (e. g. piston mass or spring stiffness) has to be parametered. There is also a heat transfer with the environment which has to take into account.

The length of the springs is parametered under condition. So the pretensioning can be adjusted.

Spring 1 works, if

$$\text{Stroke} = \text{Strokemin} - \text{DeadStroke1} + \text{SpringLength1} ,$$

and spring 2 works, if

$$\text{Stroke} = \text{Strokemax} + \text{DeadStroke2} - \text{SpringLength2} .$$

Pay attention the *DeadStroke* has to be positive every time.

The friction of the cylinder has to be modeled in the connected system (internal or external).

The cylinder has end position dampings on both sides, which are active, unless the parameters *EndPositionDampingActiv1* and *EndPosition Damping2Activ* are composed to values unequal zero.

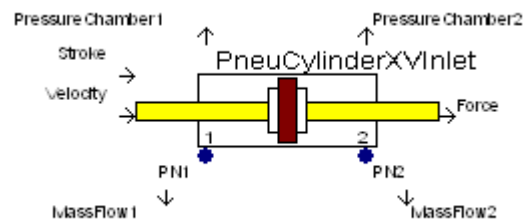
The *EndPositionDamping* becomes activated, when the damping piston moves into the damping bush before reaching the end position, and the direct connection between the cylinder chamber and the extracted air is interrupted. While moving into the end position the air of the piston can only flow out through the throttle, therefore the piston movement is slowed down. During moving out of the end position the air is able to flow unthrottled through the parallel check valve into the cylinder chamber, so there is hardly no delay.

The flow characteristics of the *EndPositionDampings* are described by parameters through conductances, critical pressure ratios and the opening of the damping throttle.

If a differential cylinder should be modelled, only the rod diameter, has to be set to zero. To this cylinder side the external leakage automatically is set to zero. A differential cylinder could be represented with an own component symbol.

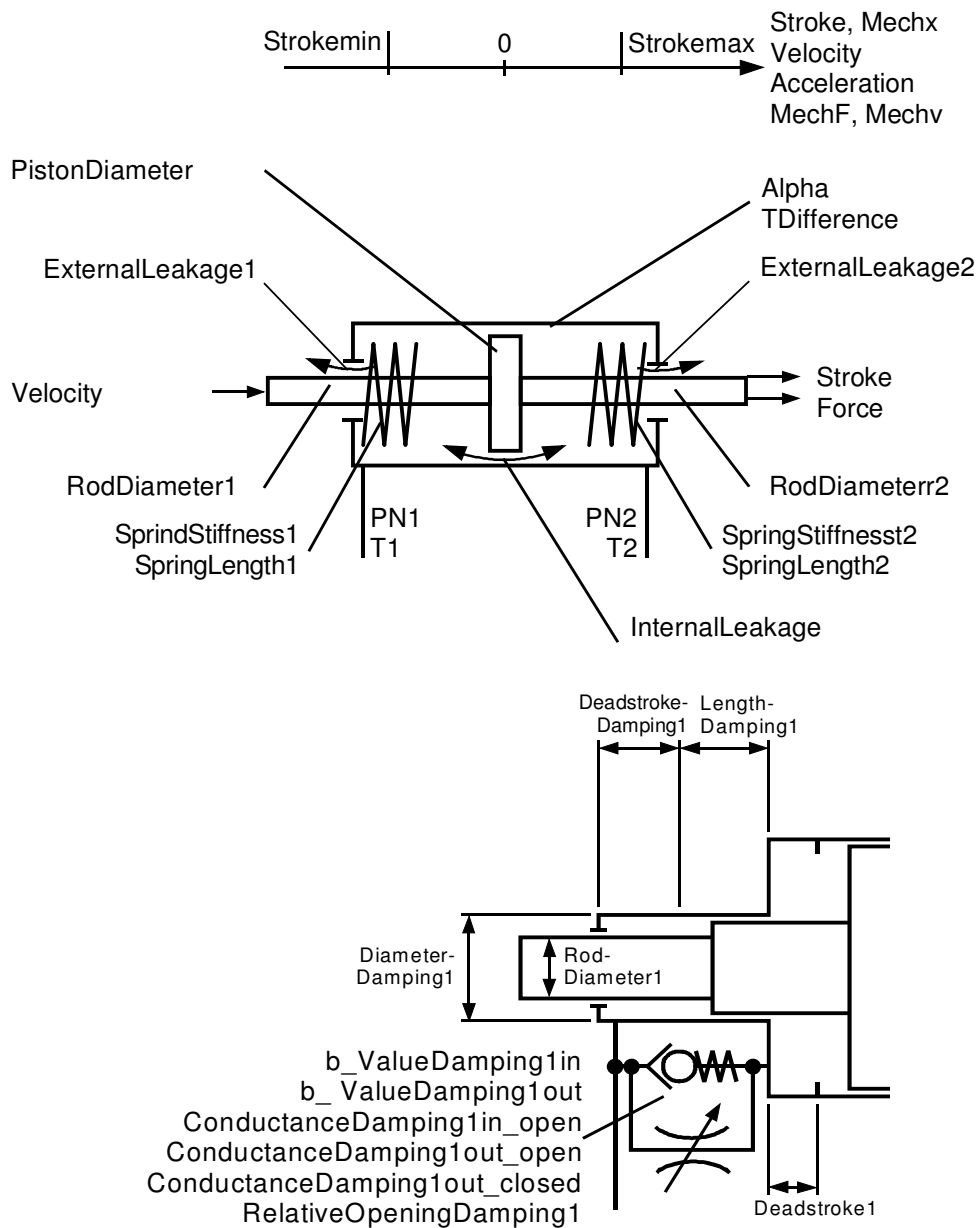
In the mechanical connector *Mech* of the component the stroke of the cylinders (*Mechx*), the velocity (*Mechv*) and the load (*MechF*) are summarized.

PneuCylinderXVInlet



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
ChamberPressure1	V-Out	bar	pressure in the cylinder chamber 1
ChamberPressure2	V-Out	bar	pressure in the cylinder chamber 2
ChamberTemp1	V	K	temperature in the cylinder chamber 1
ChamberTemp2	V	K	temperature in the cylinder chamber 2
Velocity	In	m/s	velocity of the piston
Stroke	In	mm	stroke of the piston
Force	Out	N	force which is delivered from the cylinder
Mech	Mech	-	mechanical connector
MechF	In	N	force which takes effect on the piston
Mechx	Out	mm	stroke of the piston
Mechv	Out	m/s	velocity of the piston
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
PistonDiameter	50	mm	diameter of the cylinder piston
RodDiameter1	10	mm	diameter of the cylinder rod 1
RodDiameter2	10	mm	diameter of the cylinder rod 2
Strokemax	100	mm	maximum stroke of the piston in positive direction
Strokemin	0	mm	maximum stroke of the piston in negative direction

Name	Value	Unit	Description
DeadStroke1	0	mm	length of the dead volume at the cylinder side 1
DeadStroke2	0	mm	length of the dead volume at the cylinder side 2
SpringStiffness1	0	N/mm	stiffness of the spring 1
SpringStiffness2	0	N/mm	stiffness of the spring 2
SpringLength1	50	mm	unstretched length of the spring 1
SpringLength2	50	mm	unstretched length of the spring 2
Alpha	75	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
ExternalLeakage1	0.01	NI/min/ bar	pressure dependent leakage at the rod seal 1
ExternalLeakage2	0.01	NI/min/ bar	pressure dependent leakage at the rod seal 2
InternalLeakage	0.01	NI/min/ bar	pressure dependent leakage at the piston seal
EndPositionDamping1Activ	0	-	switch for end position damping at cylinder side 1 activ
EndPositionDamping2Activ	0	-	switch for end position damping at cylinder side 2 activ
DiameterDamping1	20	mm	diameter of the damping chamber 1
DiameterDamping2	20	mm	diameter of the damping chamber 2
LengthDamping1	20	mm	active length of the damping chamber 1
LengthDamping2	20	mm	active length of the damping chamber 2
DeadStrokeDamping1	0	mm	dead length of the damping chamber 1
DeadStrokeDamping2	0	mm	dead length of the damping chamber 2

Name	Value	Unit	Description
b_ValueDamping1In	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from cylinder chamber 1 to the connector 1
b_ValueDamping2In	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from cylinder chamber 2 to the connector 2
b_ValueDamping1Out	0.528	-	critical pressure ratio of a flow through the damping 1 to the flow direction from connector1 to the cylinder chamber 1
b_ValueDamping2Out	0.528	-	critical pressure ratio of a flow through the damping 2 to the flow direction from connector 2 to the cylinder chamber 2
ConductanceDamping1-In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping2-In_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the cylinder chamber 1 to the connector 1
ConductanceDamping1-Out_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from connector 1 the to the cylinder chamber 1
ConductanceDamping2-Out_open	1	NI/s/bar	conductance of the damping 1 at maximum opening to a flow from the connector 1 to the cylinder chamber 1
ConductanceDamping1-Out_closed	1	NI/s/bar	conductance of the damping 1 at closed throttle to a flow from the connector 1 to the cylinder chamber 1

Name	Value	Unit	Description
ConductanceDamping 2-Out_closed	1	NI/s/bar	conductance of the damping 2 at closed throttle to a flow from the connector 2 to the cylinder chamber 2
RelativeOpening-Damping1	50	%	relative opening of the damping throttle 1
Relative Opening-Opening2	50	%	relative opening of the damping throttle 2
PolytropicExponent	1.4	-	polytropic exponent of the gas

Notes

The component **PNEUCYLINDERXVINLET** is a model of a pneumatic synchronizing or differential cylinder, which could be has an *EndPositionDamping* on both sides. The velocity and the stroke of the piston are an output value, the force generating the cylinder, is calculated.

The component is created in the same physical construction like a cylinder, so the physical characteristic values (e.g. piston mass or spring stiffness) has to be parametered. There is also a heat transfer with the environment.

The length of the springs is parametered under condition. So the pretensioning can be adjusted.

Spring 1 works, if

$$Stroke = Strokemin - DeadStroke1 + SpringLength1 ,$$

and spring 2 works, if

$$Stroke = Strokemax + DeadStroke2 - SpringLength2 .$$

Pay attention the *DeadStroke* has to be positive every time.

The friction of the cylinder has to be modeled in the connected system (internal or external).

The cylinder has *EndPositionDampings* on both sides, which are active, unless the parameters *EndPositionDamping1Available* and *EndPositionDamping2available* are composed to values unequal zero.

The *EndPositionDamping* becomes activated, when the damping piston moves into the damping bush before reaching the endposition, and the direct connection between the cylinder chamber and the extracted air is interrupted. While moving into the endposition the air of the piston only flows out through the throttle, therefore the piston movement is slowed down. During moving out of the EndPosition the air is able to flow unthrottled through the parallel check valve into the cylinder chamber, so there is hardly no delay.

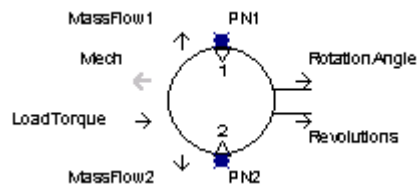
The flow characteristics of the *EndPositionDampings* are described by parameters through conductances, the critical pressure ratios and the opening of the damping throttle.

If a differential cylinder should be modelled, only the rod diameter, has to be set to zero. To this cylinder side the external leakage automatically is set to zero. A differential cylinder could be represented with an own component symbol.

In the mechanical connector *Mech* of the component the stroke of the cylinders (*Mechx*), the velocity (*Mechv*) and the load (*MechF*) are summarized.

Rotational Motors

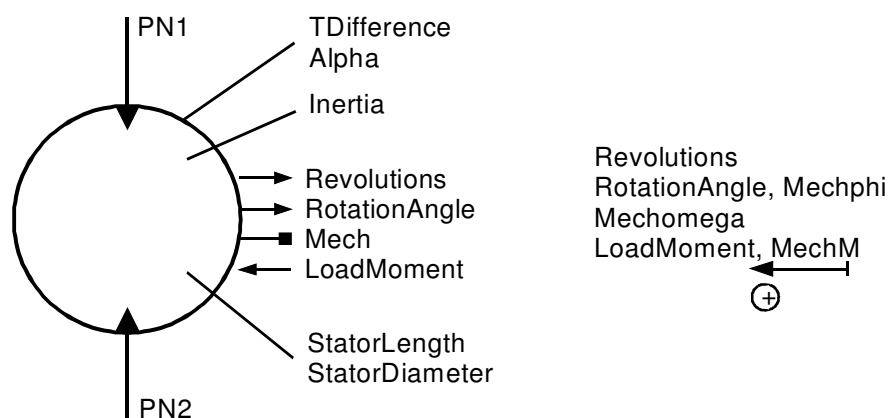
PneuVaneMotor



PneuVaneMotor

Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
LoadTorque	In	Nm	torque which takes effect on the motor
Revolutions	V-Out	1/min	revolutions of the motor
RotationAngle	V-Out	deg	rotation angle of the motor
Mech	Mech	-	mechanical connector
MechM	In	Nm	torque which takes effect on the motor
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
NominalTorque	5	Nm	Operating torque
NominalSpeed	450	1/min	OperatingSpeed
IdleSpeed	900	1/min	Speed without Load
NominalPressure	7	Bar	Operating Pressure
NominalVolumeFlow	0.3	Nm ³ /min	Operating Volumeflow
ZeroVolumeFlow	0.1	Nm ³ /min	
Inertia	0.005	kgm ²	inertia of the rotating parts of the motor
StatorLength	37	mm	length of the stator
StatorDiameter	17.5	mm	diameter of the stator
Alpha	75	W/m ² /K	heat transfer number
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
Speed_Pressure_Factor	6.5	%/bar	Speed factor
Torque_Pressure_Factor	17.5	%/bar	Velocity factor

Notes

The component PNEUPNEUVANEMOTOR is a model of a pneumatic rotation motor. The model only partially has the physical construction of a vane disc motor, some physical parameters could be fall out. To the dependences of the *MotorTorque* and *VolumeFlow* only the characteristic properties of a vane disc motor are replicated. There is a heat transfer with the environment and even the inertia of the rotating motor parts is considered.

MotorTorque and *VolumeFlow* (through which the *MassFlow* is calculated) are named like two dimensional characteristics depending on the pressure difference $PN1 - PN2$ (Input 1 of the characteristic) and *Revolution* (Input 2 of the characteristic).

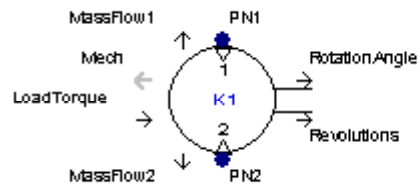
For the calculation of the heat transfer with the environment it is sold out of a cylindrical motor with the measures *StatorLength* and *StatorDiameter*.

According to the rotation direction $PN1$ as well as $PN2$ possibly designates the high pressure side of the motor. Is $PN1 > PN2$ a positive *Revolution* results. Is the *MotorTorque* > 0 a positive acceleration results.

In the mechanical connector *Mech* of the component the rotation angle of the motor (*Mechphi*), the angular velocity (*Mechomega*) and the load torque (*MechM*) are summarized.

A model of a pneumatic vane motor is even available as a component, which conduction of the *MotorTorque* and the *VolumeFlow* (through which the *MassFlow* is calculated) is named by parameters (PNEULAMELLENMOTOR).

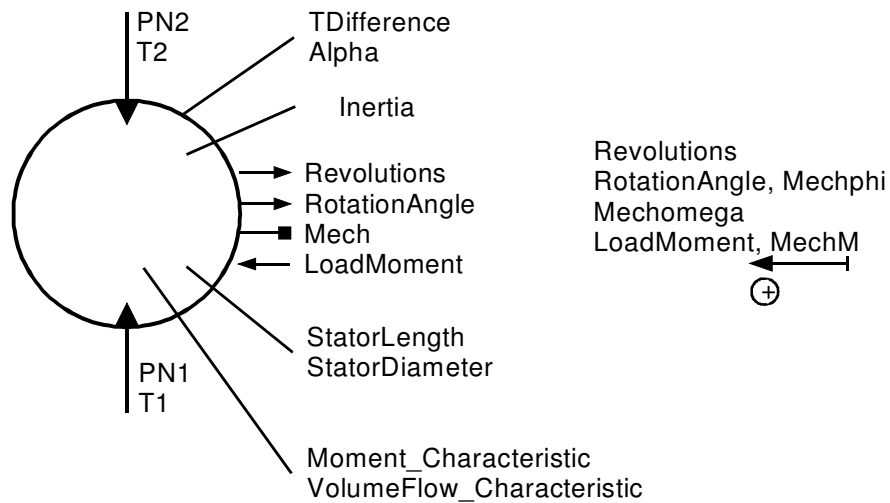
PneuVaneMotorCharacteristic1



PneuVaneMotorCharacteristic1

Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
LoadTorque	In	Nm	torque which takes effect on the motor
Revolutions	V-Out	1/min	revolutions of the motor
RotationAngle	V-Out	deg	rotation angle of the motor
Mech	Mech	-	mechanical connector
MechM	In	Nm	torque which takes effect on the motor
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MassFlow1	Out	kg/s	mass flow 1

Name	Type	Unit	Description
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
Inertia	0.005	kgm ²	inertia of the rotating parts of the motor
StatorLength	37	mm	length of the stator
StatorDiameter	17.5	mm	diameter of the stator
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
Alpha	75	W/m ² /K	heat transfer number
Torque_Characteristic	-1	-	characteristic to the <i>MotorTorque</i> depending on the pressure difference <i>PN1 – PN2</i> and the <i>Revolution</i>
VolumeFlow_Characteristic	-1	-	characteristic to the volume flow depending on the pressure difference <i>PN1 – PN2</i> and the <i>Revolution</i>

Notes

The component PNEUPNEUVANEMOTORCHARACTERISTIC1 is a model of a pneumatic rotation motor. The model only partially has the a physical construction of a vane discmotor, some physical parameters could be fall out. To the dependences of the *MotorTorque* and *VolumeFlow* only the characteristic properties of a vane discmotor are replicated. There is a heat transfer with the environment and even the inertia of the rotating motor parts is considered.

MotorTorque and *VolumeFlow* (through which the *MassFlow* is calculated) are named like two dimensional characteristics depending on the pressure difference *PN1 – PN2* (Input 1 of the characteristic) and *Revolution* (Input 2 of the characteristic).

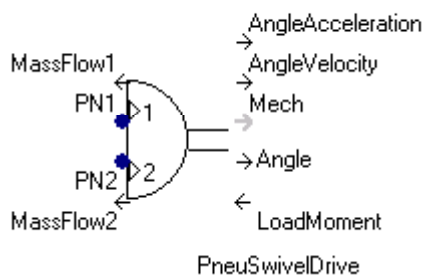
For the calculation of the heat transfer with the environment it is sold out of a cylindric motor with the measures *StatorLength* and *StatorDiameter*.

According to the rotation direction *PN1* as well as *PN2* possibly designates the high pressure side of the motor. Is *PN1 > PN2* a positive *Revolution* results. Is the *MotorTorque > 0* a positive acceleration results.

In the mechanical connector *Mech* of the component the rotation angle of the motor (*Mechphi*), the angular velocity (*Mechomega*) and the load torque (*MechM*) are summarized.

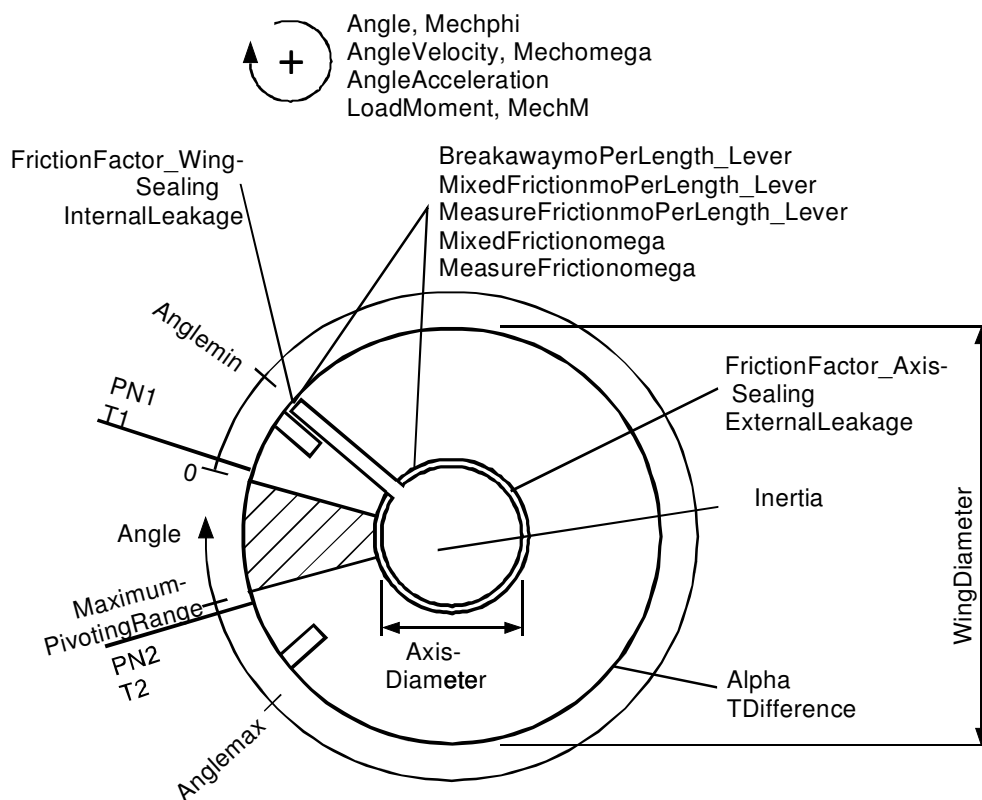
A model of a pneumatic vane motor is even available as a component, whichs conduction of the *MotorTorque* and the *VolumeFlow* (through which the *MassFlow* is calculated) is named by parameters (PNEULAMELLENMOTOR).

PneuSwivelDrive



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2

Name	Type	Unit	Description
LoadTorque	In	Nm	torque which takes effect on the swivelling axis
AngularAcceleration	Out	deg/s ²	angular acceleration of the swivelling axis
AngularVelocity	V-Out	deg/s	angular velocity of the swivelling axis
Angle	V-Out	deg	rotation angle of the swivelling axis
Mech	Mech	-	mechanical connector
MechM	In	Nm	torque which takes effect on the motor
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
AxisDiameter	24	mm	diameter of the swivelling axis
WingDiameter	50	mm	diameter of the motor
WingLength	20	mm	latitude of the motor wing
MaximumPivotingRange	180	deg	pivoting range of the motor
Anglemin	0	deg	minimum angle
Anglemax	180	deg	maximum angle
MassInertia	1E-4	kgm ²	inertia of the movable motor parts
Alpha	75	W/m ² /K	heat transfer number of the motor housing
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
BreakawayTorquePerLength_Lever	0	Nm/mm ²	characteristic value of the Stribeck-curve
MixedFrictionMoPerLength_Lever	0	Nm/mm ²	characteristic value of the Stribeck-curve
MeasureFrictionTorquePerLength_Lever	0	Nm/mm ²	characteristic value of the Stribeck-curve

Name	Value	Unit	Description
MixedFrictionOmega	1E-4	deg/s	characteristic value of the Stribeck-curve
MeasureFrictionOmega	2E-4	deg/s	characteristic value of the Stribeck-curve
FrictionFactor_WingSealing	0.5	1/bar	factor in consideration to the pressure dependence of the friction on the wing sealings
AxisSealing_Activ	0	-	switch to put on the friction force to the axis sealings
FrictionFactor_AxisSealing	0.5	1/bar	factor in consideration to the pressure dependence of the friction on the axis sealings
ExternalLeakage	0	NI/min/ bar	external pressure dependent leakage
InternalLeakage	0	NI/min/ bar	internal pressure dependent leakage

Notes

The component PNEUSWIVELDRIVE is a model of a pneumatic rotation motor, whichs friction torques of the wing and axis sealings ars calculated through Stribeck-curves. These curves are determined by parameters.

The model is a model of a physical construction of a swivel drive, why physical characteristics (e. g. Inertia and FrictionTorque) should be parametered. There also is a heat transfer with the environment which has to take into account.

The parameter *MaximumPivotingRange* determines the largest possible rotation angle area of the swivel drive. Throughout *Anglemin* and *Anglemax* key strokes are able to be adjusted in this area, *Anglemin* and *Anglemax* have to be positive. Is *Anglemin* > 0 and *Anglemax* < *MaximumPivotingRange* the dead volumina is remaining in the chambers, unless the wing drive in one of the key strokes.

For the calculation of the heat transfer with the environment it is sold out of a cylindric motor with the measures *WingDiameter* and *WingLength*.

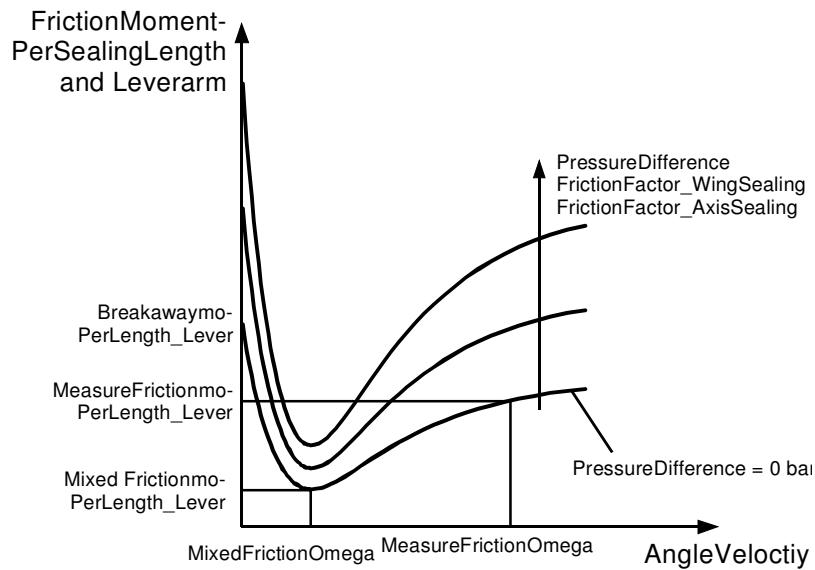
The friction torques of the wing and axis sealings are determined through Stribeck-curves. In the Stribeck-curves the friction torques are referring to the length of the sealings and the related lever arms are exaggerated through *AngularVelocity*. The sealing between wing and housing, the sealing, which seperatios both chambers of the swivel drive on the axis, and the sealings between the axis and the housing, which avoid a gas leakage out of the motor, are considered. Is the parameter *AxisSealingActiv* set to zero, the friction torque of the axis sealing is neglected.

The Stribeck-curves are produced to a pressure difference from 0 bar through the characteristic values *BreakawayMoPerLength_Lever*, *MixedFrictionMoPerLength_Lever*, *MeasureFrictionmPerLength_Lever*, *MixedFrictionOmega* and *MeasureFrictionOmega*.

The pressure dependence of the friction torques are computed by parametiring factors (*FrictionFactor_Wing-Sealing* resp. *FrictionFactor_AxisSealing*):

$$FrictionTorque_{Pressure\ difference \neq 0} =$$

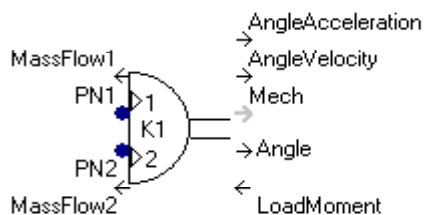
$= FrictionTorque_{pressure\ difference = 0} (1 + |Pressuredifferenz| \cdot Factor)$. In the following figure the Stribeck-curve is described:



In the mechanical connector *Mech* of the component the rotation angle of the motor (*Mechphi*), the angular velocity (*Mechomega*) and the load torque (*MechM*) are summarized.

A modelI of a pneumatic swivel drive is even available as a component, whichs characteristic values of the Stribeck-curve are described by characteristics depending on the pressure difference (PNEUSWIVELDRIVETABLE 1). In the component PNEUSWIVELDRIVETABLE 2 the friction torques of the sealings are shown through two dimensional characteristics depending on pressure difference and angular velocity.

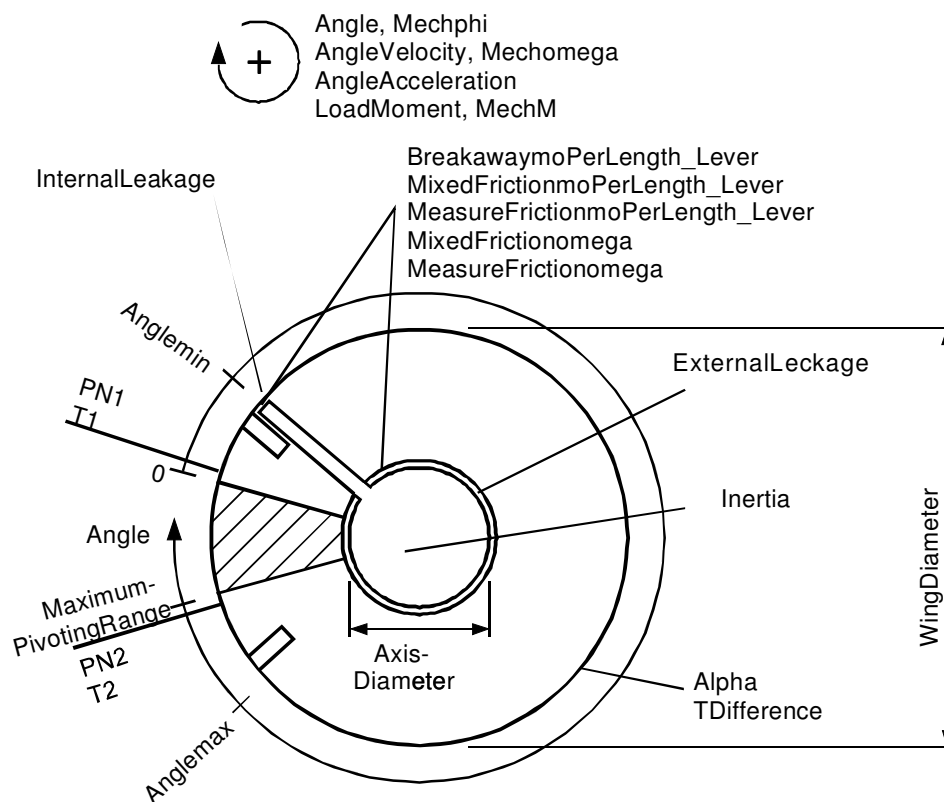
PneuSwivelDriveFrictionTable1



PneuSwivelDriveFrictionTable1

Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1

Name	Type	Unit	Description
T2	Pneu	K	temperature of the gas in connector 2
LoadTorque	In	Nm	torque which takes effect on the swivelling axis
AngularAcceleration	Out	deg/s ²	angular acceleration of the swivelling axis
AngularVelocity	V-Out	deg/s	angular velocity of the swivelling axis
Angle	V-Out	deg	rotation angle of the swivelling axis
Mech	Mech	-	mechanical connector
MechM	In	Nm	torque which takes effect on the motor
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
AxisDiameter	24	mm	diameter of the swivelling axis
WingDiameter	50	mm	diameter of the motor
WingLength	20	mm	latitude of the motor wing
MaximumPivotingRange	180	deg	pivoting range of the motor
Anglemin	0	deg	minimum angle
Anglemax	180	deg	maximum angle
MassInertia	1E-4	kgm ²	inertia of the movable motor parts
Alpha	75	W/m ² /K	heat transfer number of the motor housing
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
BreakawayMo_- Characteristic	-1	-	characteristic to a characteristic value of the Stribeck-curve depending on pressure difference which takes effect on the sealing

Name	Value	Unit	Description
MixedFrictionmo_- Characteristic	-1	-	characteristic to a characteristic value of the Stribeck-curve depending on pressure difference which takes effect on the sealing
MeasureFrictionMo_Characteristic	-1	-	characteristic to a characteristic value of the Stribeck-curve depending on pressure difference which takes effect on the sealing
MixedFrictionOmega_Characteristic	-1	-	characteristic to a characteristic value of the Stribeck-curve depending on pressure difference which takes effect on the sealing
MeasureFrictionOmega_Characteristic	-1	-	characteristic to a characteristic value of the Stribeck-curve depending on pressure difference which takes effect on the sealing
AxisSealingsActiv	0	-	switch to put on the friction force to the axis sealings
ExternalLeakage	0	NI/min/ bar	external pressure dependent leakage
InternalLeakage	0	NI/min/ bar	internal pressure dependent leakage

Notes

The component PNEUSWIVELDRIVEFRICTIONTABLE1 is a model of a pneumatic swivel motor, whichs friction torques of the wing and axis sealings ars calculated through Stribeck-curves. The characteristic values of the curves are determined by characteristics depending on pressure.

The model is a model of a physical construction of a swivel drive, why physical characteristics (e. g. *Inertia* and *FrictionTorque*) should be parametered. There is also a heat transfer with the environment which has to take into account.

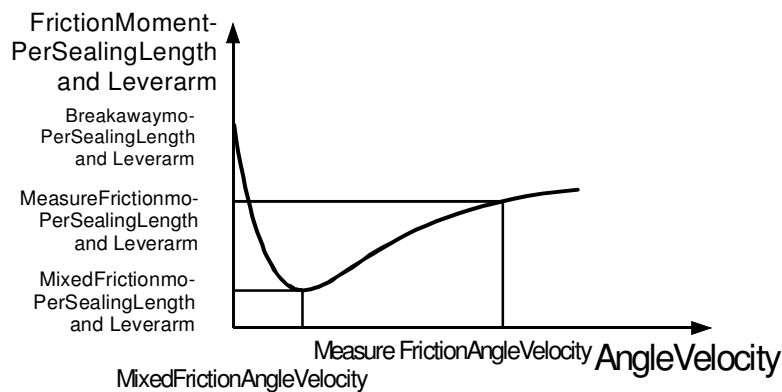
The parameter *MaximumPivotingRange* determines the largest possible rotation angle area of the swivel drive. Throughout *Anglemin* and *Anglemax* key strokes are able to be adjusted in this area, *Anglemin* and *Anglemax* have to be positive. Is *Anglemin* > 0 and *Anglemax* < *MaximumPivotingRange* the dead volumina is remaining in the chambers, unless the wing drives in one of the key strokes.

For the calculation of the heat transfer with the environment it is sold out of a cylindric motor with the measures *WingDiameter* and *WingLength*.

The friction torques of the wing and axis sealings are determined through Stribeck-curves. In the Stribeck-curves the friction torques are referring to the length of the sealings and the related lever arms are exaggerated through *AngularVelocity*. The sealing between wing and housing, the sealing, which separates both chambers of the swivel drive on the axis, and the sealings between the axis and the housing, which avoid a gas leakage out of the motor, are considered. If the parameter *AxisSealingActiv* is set to zero, the friction torque of the axis sealing is neglected.

From the characteristics *BreakawayMo_Characteristic*, *MixedFrictionMo_Characteristic*, *MeasureFrictionMo_Characteristic*, *MixedFrictionOomega_Characteristic* und *MeasureFrictionOmgma_Characteristic*, the characteristic values depending on the respective sealings adjacent pressure differences are extracted. These characteristic values generate the Stribeck-curves.

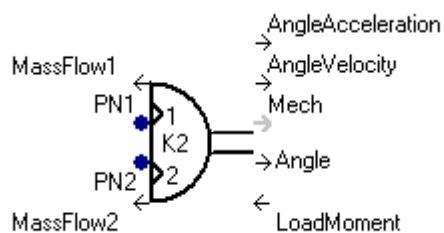
In the following figure the Stribeck-curve is described with characteristic values produced through the characteristics:



In the mechanical connector *Mech* of the component the angle of the motor (*Mechphi*), the angular velocity (*Mechomega*) and the load torque (*MechM*) are summarized.

A model of a pneumatic swivel drive is even available as a component, whichs friction torques of the sealings are calculated through a difference pressure dependent Stribeck-curve, whichs characteristic values are parameters (PNEUSWIVELLINGDRIVE). In the component PNEUSWIVELDRIVEFRICTIONTABLE2 the friction torques of the sealings are shown through two dimensional characteristics depending on pressure difference and angular velocity.

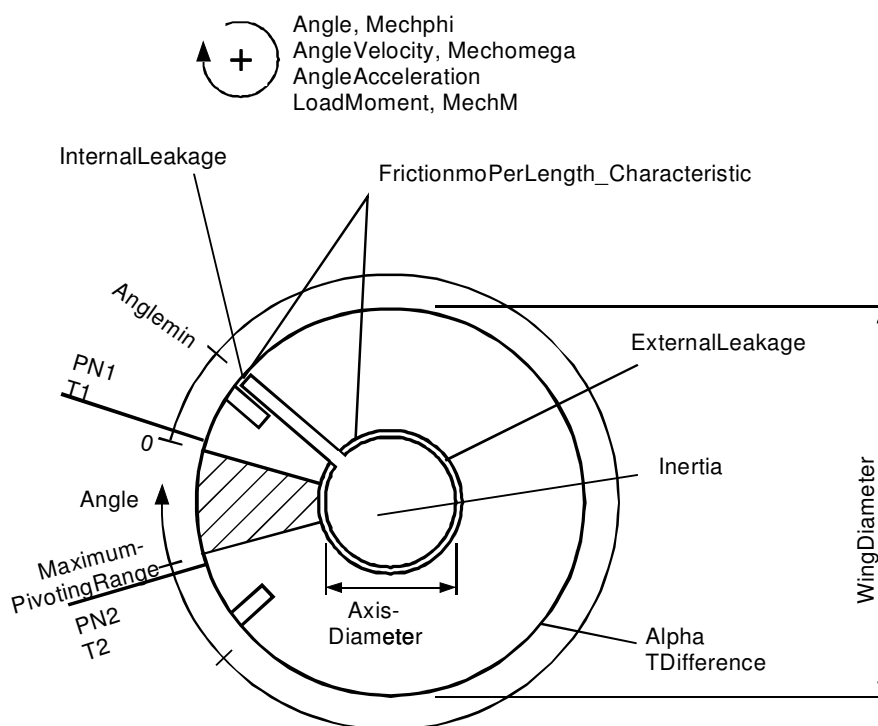
PneuSwivelDriveFrictionTable2



PneuSwivelDriveFrictionTable2

Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
LoadTorque	In	Nm	torque which takes effect on the swivelling axis

Name	Type	Unit	Description
AngularAcceleration	Out	deg/s ²	angular acceleration of the swivelling axis
AngularVelocity	V-Out	deg/s	angular velocity of the swivelling axis
Angle	V-Out	deg	rotation angle of the swivelling axis
Mech	Mech	-	mechanical connector
MechM	In	Nm	torque which takes effect on the motor
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MassFlow1	Out	kg/s	mass flow 1
MassFlow2	Out	kg/s	mass flow 2

Parameters

Name	Value	Unit	Description
AxisDiameter	24	mm	diameter of the swivelling axis
WingDiameter	50	mm	diameter of the motor
WingLength	20	mm	latitude of the motor wing
MaximumPivoting Range	180	deg	pivoting range of the motor
Anglemin	0	deg	minimum angle
Anglemax	180	deg	maximum angle
MassInertia	1E-4	kgm ²	inertia of the movable motor parts
Alpha	75	W/m ² /K	heat transfer number of the motor housing
TDifference	0	K	difference between the cylinder side temperature and the temperature of the environment
FrictionTorquePerLength_Characteristic	-1	-	characteristic to the friction torque of the sealings referring to their length depending on pressure difference which takes effect on it and the angular velocity

Name	Value	Unit	Description
AxisSealingsActiv	0	-	switch to put on the friction force to the axis sealings
ExternalLeakage	0	NI/min/ bar	external pressure dependent leakage
InternalLeakage	0	NI/min/ bar	internal pressure dependent leakage

Notes

The component PNEUSWIVELDRIVEFRICTIONTABLE2 is a model of a pneumatic swivel motor, whichs friction torques of the wing and axis sealings are determined through a characteristic depending on the pressure difference and the angular velocity.

The model is a model of a physical construction of a swivel drive, why physical characteristics (e.g. *TorquesOfInertia* and *FrictionTorques*) should be parametered. There is also a heat transfer with the environment which has to take into account.

The friction torques of the wing and axis sealings are determined through Stribeck-curves. In the Stribeck-curves the friction torques are referring to the length of the sealings and the related lever arms are exaggerated through *AngularVelocity*. The sealing between wing and housing, the sealing, which seperatios both chambers of the swivel drive on the axis, and the sealings between the axis and the housing, wich avoid a gas leakage out of the motor, are considered. Is the parameter *AxisSealingActiv* set to zero, the friction torque of the axis sealing is neglected.

For the calculation of the heat transfer with the environment it is sold out of a cylindric motor with the measures *WingDiameter* and *WingLength*.

The parameter *MaximumPivotingRange* determines the largest possible rotation angle area of the swivel drive. Throughout *Anglemin* and *Anglemax* key strokes are able to be adjusted in this area, *Anglemin* and *Anglemax* have to be positive. Is *Anglemin* > 0 and *Anglemax* < *MaximumPivotingrange* the dead volumina is remaining in the chambers, unless the wing drives in one of the key strokes.

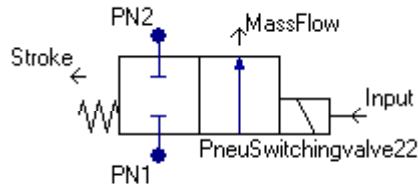
In the mechanical connector *Mech* of the component the angle of the motor (*Mechphi*), the angular velocity (*Mechomega*) and the load torque (*MechM*) are summarized.

A modelI of a pneumatic swivel drive is even available as a component, whichs friction torques of the sealings are calculated through a difference pressure dependent Stribeck-curve, whichs characteristic values are parameters (PNEUSWIVELDRIVE), or through characteristics depending on pressure difference (PNEUSWIVELDRIVEFRICTIONTABLE1).

Directional Valves

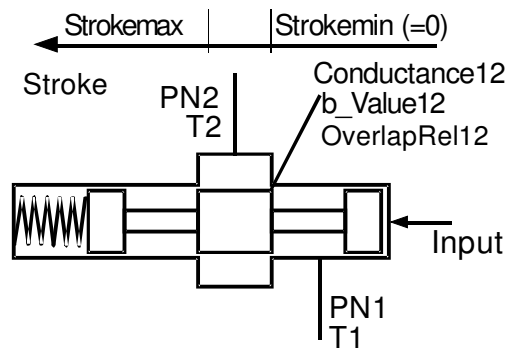
2-x Valves

PneuSwitchingvalve22



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal of the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the valve

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (in this place each time <i>strokemin = 0</i>)
OverlapRel12	0	%	relative overlap of the metering edge at <i>stroke = strokemin = 0</i>
PolytropicExponent	1.4	-	Polytropic exponent of the piston
Conductance12	1	NI/s/bar	conductance of the valve at <i>stroke = strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow through the vale

Notes

The component SWITCHINGVALVE22 is a model of a 2/2-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristic of the valve is defined by conductance (*Conductance12*), critical pressure ratio (*b_Value12*), and relative overlap (*OverlapRel12*).

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input > 0* the valve switches in positive direction up to *Stroke = Strokemax*, for *Input ≤ 0* the valve switches in negative direction up to *Stroke = Strokemin*. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin > Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The parameters of the relative overlap *OverlapRel12* define, about how much percent in connection to *Strokemax* the steering wheel spool covers the metering edge resp. set free the cross-section of the opening.

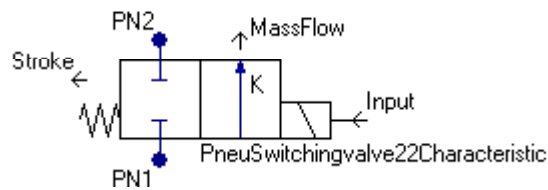
The following rule is effective:

OverlapRel12 < 0: Valve at *Stroke = Strokemin* opened
OverlapRel12 = 0: Valve at *Stroke = Strokemin* just closed
OverlapRel12 > 0: Valve at *Stroke = Strokemin* closed

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

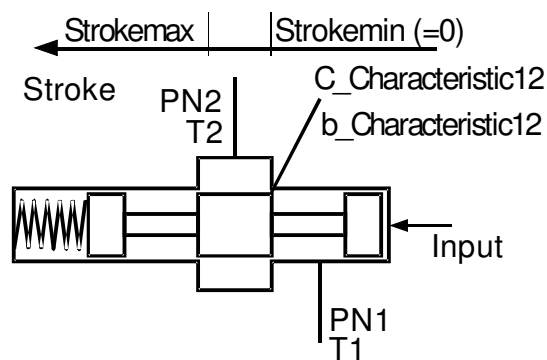
A model of a pneumatic 2/2-directional switching valve is available as a component; which's flow characteristic of the metering edge is defined by look-up tables to conductance and critical pressure ratio (PNEUSWITCHINGVALVE22CHARACTERISTIC).

PneuSwitchingvalve22Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal of the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the valve

Parameters

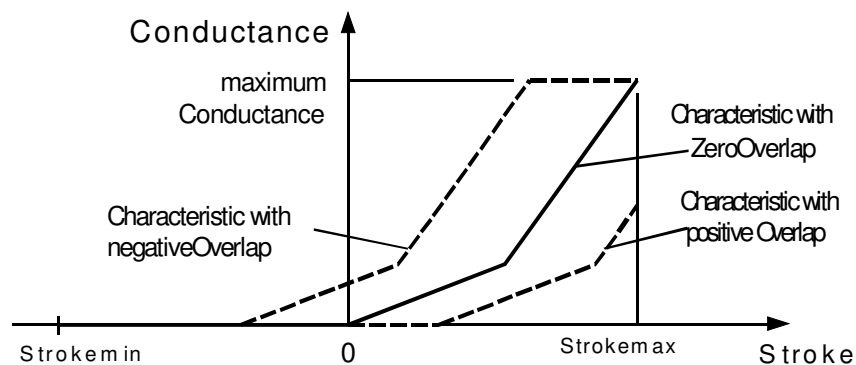
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	0	mm	minimum spool stroke (in this place each time $strokemin = 0$)
PolytropicExponent	1.4	-	polytropic exponent of the piston
C_Characteristic12	-1		look-up table of the conductance of the valve in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	flow through the vale in dependence of <i>Stroke</i>

Notes

The component SWITCHINGVALVE22CHARACTERISTIC is a model of a 2/2-directional switching valve. The flow characteristic of the valve is defined by look-up tables to conductance (C_Characteristic) and critical pressure ratio (b_Characteristic).

The overlap of the metering edge has to be considered by the look-up table. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

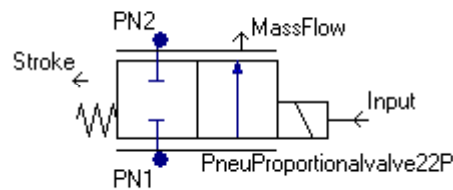
For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin$. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the $Strokemin > Strokemax$, the stroke limits are transferred inside. Both processes are pointed out by message windows.

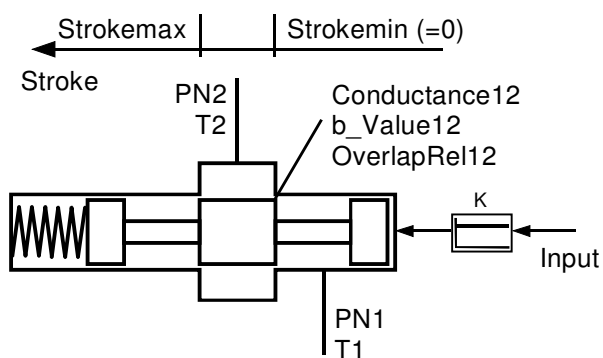
The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

A model of a pneumatic 2/2-directional switching valve is available as a component; which's flow characteristic of the metering edge is defined by look-up tables to conductance and critical pressure ratio (PNEUSWITCHINGVALVE22CHARACTERISTIC).

PneuProportionalvalve22P

**Symbol**

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal of the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the vale

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (in this place each time $strokemin = 0$)
InputMax	1	-	input signal at $Stroke = Strokemax$

OverlapRel12	0	%	relative overlap of the metering edge at <i>Stroke = Strokemin = 0</i>
PolytropicExponent	1.4	-	polytropic exponent of the piston
Conductance12	1	NI/s/bar	conductance of the valves at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow through the vale

Notes

The component PNEUPROPORTIONALVALVE22P is the model of a pneumatic 2/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristic of the valve is defined by parameters to conductance (*Conductance12*), critical pressure ratio (*b_value12*) and relative overlap (*OverlapRel12*).

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$Stroke = K \cdot Input$$

$$\text{with } K = Strokemax/InputMax$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: valve at stroke = *Strokemin* opened

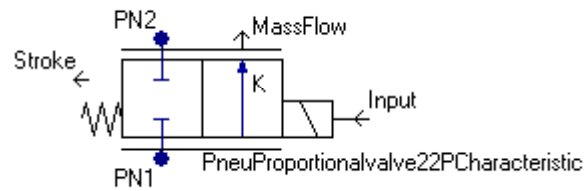
OverlapRel12 = 0: valve at stroke = *Strokemin* just closed

OverlapRel12 > 0: valve at stroke = *Strokemin* closed

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

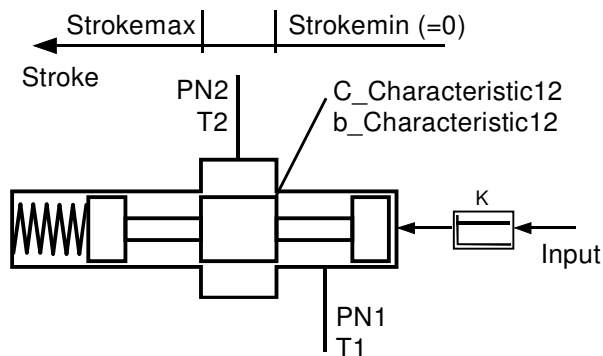
A model of this pneumatic 2/2-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristic of the metering edge is defined by look-up tables to conductance and critical pressure ratio.(PNEUPROPORTIONALVALVE22PCHARACTERISTIC).

PneuProportionalvalve22PCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the vale

Parameters

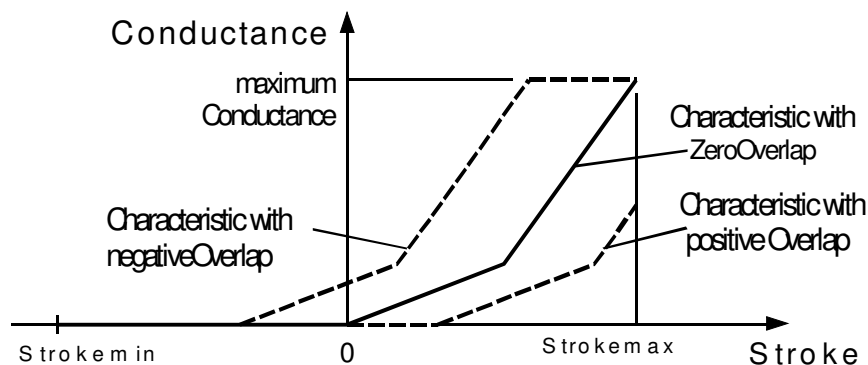
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time $Strokemin = 0$)
InputMax	1	-	input signal at $Stroke = Strokemax$

Name	Value	Unit	Description
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the valve in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table of the critical pressure ratio of the flow through the vale in dependence of <i>Stroke</i>

Notes

The component PNEUPROPORTIONALVALVE22PCHARACTERISTIC is the model of a pneumatic 2/2-directional proportional valve. The spool stroke is proportional without any delay to the input signal.

The flow characteristic of the valve is defined by a look-up table to conductance (*Conductance12*), critical pressure ratio (*b_Value12*) and relative overlap (*OverlapRel12*). An overlap of the metering edge has to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

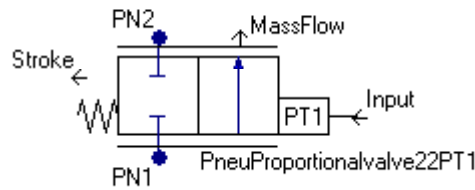
$$Stroke = K \cdot Input$$

$$\text{with } K = Strokemax / InputMax$$

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

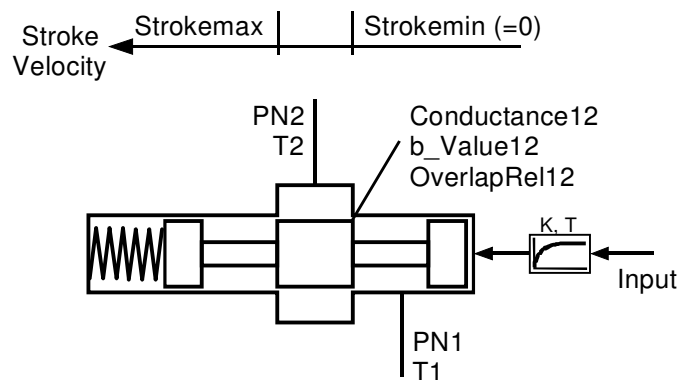
A model of the pneumatic 2/2- directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristic of the metering edge is named by parameters to conductance, critical pressure ratio and relative overlap (PNEUPROPORTIONALVALVE22P).

PneuProportionalvalve22PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	Working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the valve

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)

Name	Value	Unit	Description
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
OverlapRel12	0	%	relative Overlap of the metering edge at <i>Stroke = Strokemin = 0</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the valve at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow through the vale
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE22PT1 is the model of a pneumatic 2/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristic of the valve is defined by conductance (*Conductance12*), critical pressure ratio (*b_Value12*), and relative overlap (*OverlapRel12*).

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor *K* and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = Strokemax/InputMax.$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: Valve at *Stroke = Strokemin* opened

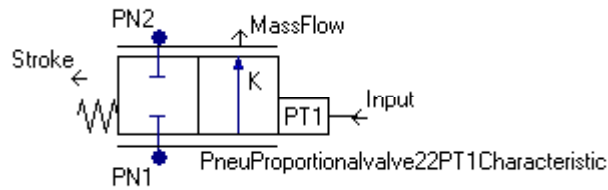
OverlapRel12 = 0: Valve at *Stroke = Strokemin* just closed

OverlapRel12 > 0: Valve at *Stroke = Strokemin* closed

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

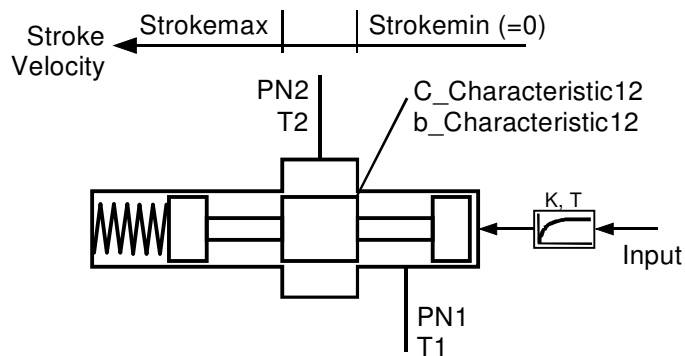
A model of this pneumatic 2/2-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristic of the metering edge is named by look-up tables to conductance and critical pressure ratio (PNEUPROPORTIONALVALVE22PT1 CHARACTERISTIC).

PneuProportionalvalve22PT1Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the valve

Parameters

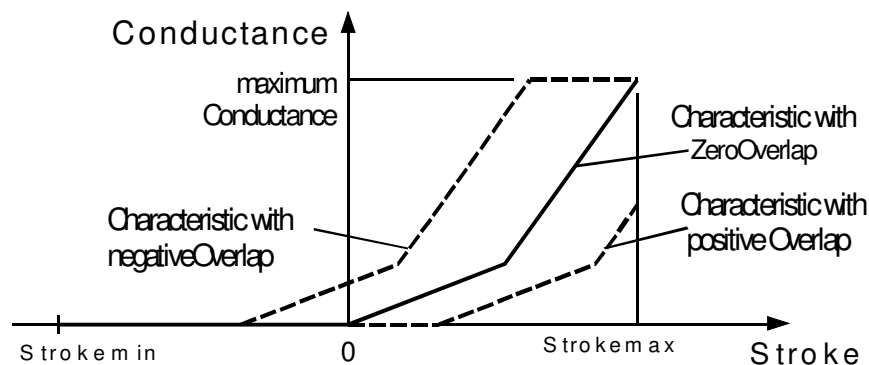
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)

Name	Value	Unit	Description
InputMax	1	-	input signal at $Stroke = Stroke_{max}$
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the valve in dependence of $Stroke$
b_Characteristic12	-1	-	look-up table of the critical pressure ratio of the flow through the valve in dependence of $Stroke$
TimeConstant	10	ms	parameter to the control characteristic (T)

Notes

The component PNEUPROPORTIONALVALVE22PT1CHARACTERISTIC is the model of a pneumatic 2/2-directional proportional valve. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristic of the valve is defined by a look-up table to conductance and critical pressure ratio ($C_Characteristic12$ and $b_Characteristic12$). An overlap of the metering edge has to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the $Stroke_{min}$ defined with a value unequal zero, stroke limits are automatically displaced to zero. Is the $Stroke_{min} > Stroke_{max}$, stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT_1 -behavior is determined by $TimeConstant$ and the proportional factor K between the $Input$ and the $Stroke$ of the spool.

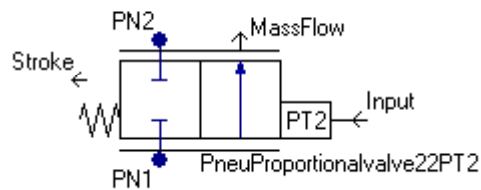
$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = Stroke_{max} / InputMax.$$

The state variable $MassFlow$ correlates to the connector $PN2$, i.e. a positive $MassFlow$ means a flow direction from $PN1$ to $PN2$.

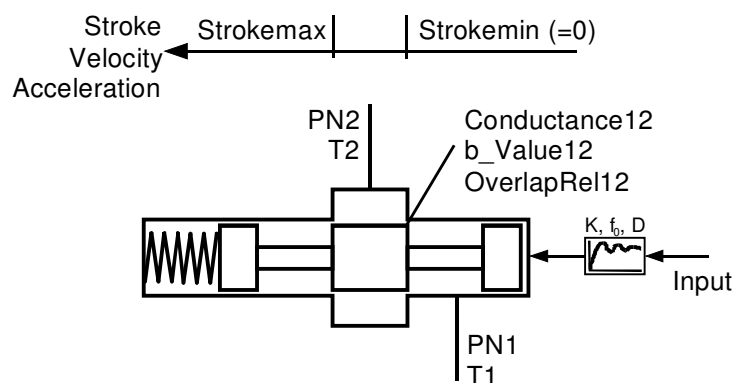
A model of the pneumatic 2/2-directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristic of the metering edge is named by parameters to conductance, critical pressure ratio and relative overlap (PNEUPROPORTIONALVALVE22PT1).

PneuProportionalvalve22PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the valve

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge at <i>Stroke</i> = <i>Strokemin</i> = 0
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the valve at <i>Stroke</i> = <i>Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow through the vale
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control(f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE22PT2 is the model of a pneumatic 2/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristic of the valve is defined by conductance (*Conductance12*), critical pressure ratio (*b_Value12*), and relative overlap (*OverlapRel12*).

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2} \frac{(2\pi \text{EigenFrequency})^2}{\text{damping} (2\pi \text{EigenFrequency}) - (2\pi \text{EigenFrequency})^2 \text{Stroke}} \text{Input Velocity}$$

with $K = \text{Strokemax}/\text{InputMax}$.

The *Velocity* and the *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

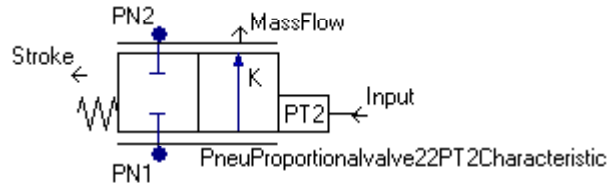
The following rule is effective:

OverlapRel12 < 0: Valve at *Stroke* = *Strokemin* opened
OverlapRel12 = 0: Valve at *Stroke* = *Strokemin* just closed
OverlapRel12 > 0: Valve at *Stroke* = *Strokemin* closed

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

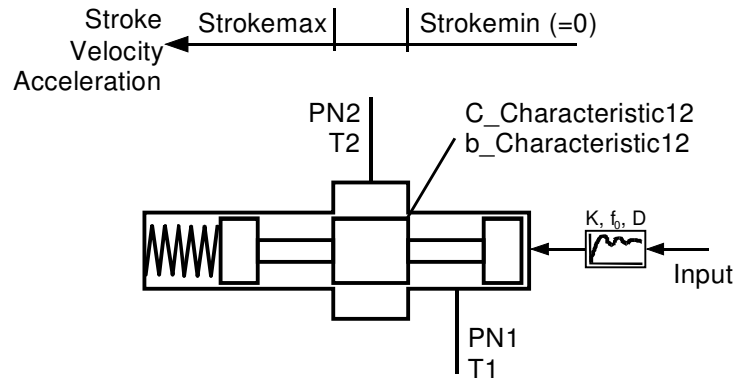
A model of this pneumatic 2/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the second order, is available as a component, which's flow characteristic of the metering edge is named by look-up tables to conductance and critical pressure ratio (PNEUPROPORTIONALVALVE22PT2 CHARACTERISTIC).

PneuProportionalvalve22PT2Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow	Out	kg/s	mass flow through the vale

Parameters

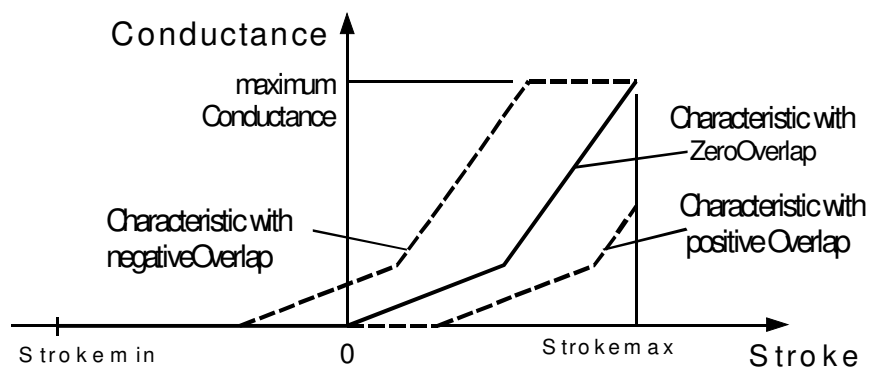
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	0	mm	minimum spool stroke (here each time $Strokemin = 0$)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at $Stroke = Strokemax$
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the valve in dependence of $Stroke$
b_Characteristic12	-1	-	look-up table of the critical pressure ratio of the flow through the valve in dependence of $Stroke$
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE22PT2CHARACTERISTIC is the model of a pneumatic 2/2-directional proportional valve. The spool stroke is proportional to the input signal, with a delay of the second order .

The flow characteristic of the valve is defined by a look-up table to conductance ($Conductance12$), critical pressure ratio ($b_Value12$) and relative overlap ($OverlapRel12$). An overlap of the metering edge has to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* *f₀*, *Damping D* and proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2 \cdot \text{damping}} \frac{(2\pi \cdot \text{EigenFrequency})^2}{(2\pi \cdot \text{EigenFrequency})^2} \text{Input Velocity} - (2\pi \cdot \text{EigenFrequency})^2 \text{Stroke}$$

with $K = \text{Strokemax}/\text{InputMax}$.

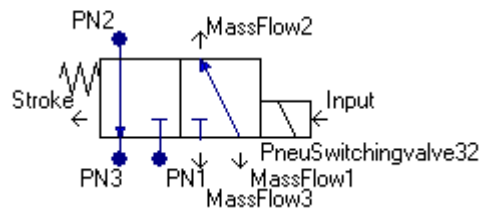
The *Velocity* and the *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*

The state variable *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

A model of the pneumatic 2/2-directional proportional valve, which's spool stroke is proportional to the input signal with a delay of the second order, is available as a component, which's flow characteristic of the metering edge is named by parameters to conductance, critical pressure ratio and relative overlap (PNEUPROPORTIONALVALVE22PT2).

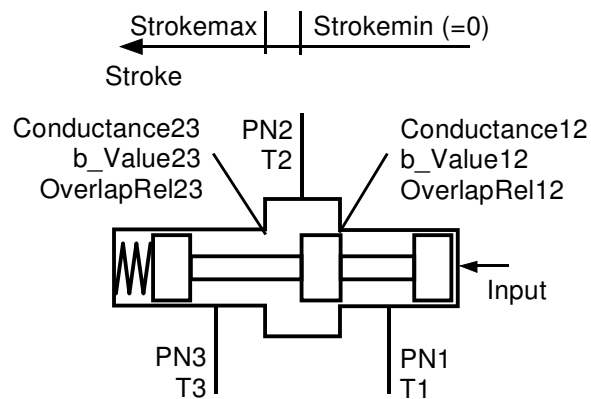
3-x-Valves

PneuSwitchingvalve32



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector1
T2	Pneu	K	temperature in connector2
T3	Pneu	K	temperature in connector3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemin</i> (= 0)
OverlapRel23	0	%	relative Overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3

Notes

The component PNEUSWITCHINGVALVE32 is the model of a pneumatic 3/2-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristic of the valve is defined by conductance and critical pressure ratio.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin$. The opening of the valve lasts always $SwitchingTimeOpen$, the closing always $SwitchingTimeClose$. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the $Strokemin$ defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the $Strokemin > Strokemax$, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap $OverlapRel12$ defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

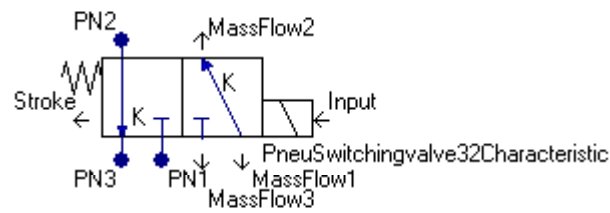
The following rule is effective:

$OverlapRel12 < 0$: metering edge = $Strokemin$ opened
 $OverlapRel12 = 0$: metering edge = $Strokemin$ just closed
 $OverlapRel12 > 0$: metering edge = $Strokemin$ closed

Take notice about that the $OverlapRel12$ is valid to $Stroke = Strokemin = 0$ and the $OverlapRel23$ to $Stroke = Strokemax$.

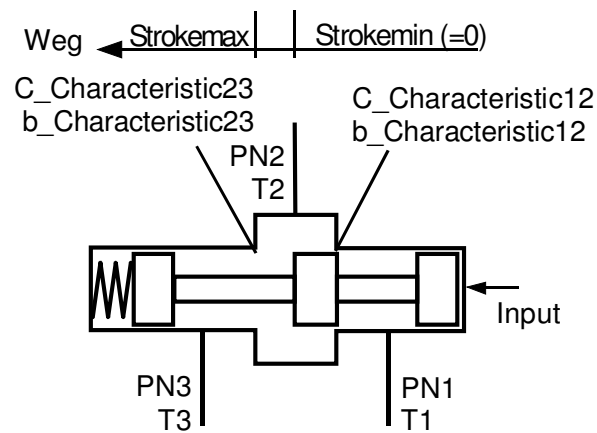
A model of a pneumatic 3/2-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by look-up tables to conductance and critical pressure ratio (PNEUSWITCHINGVALVE32CHARACTERISTIC).

PneuSwitchingvalve32Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

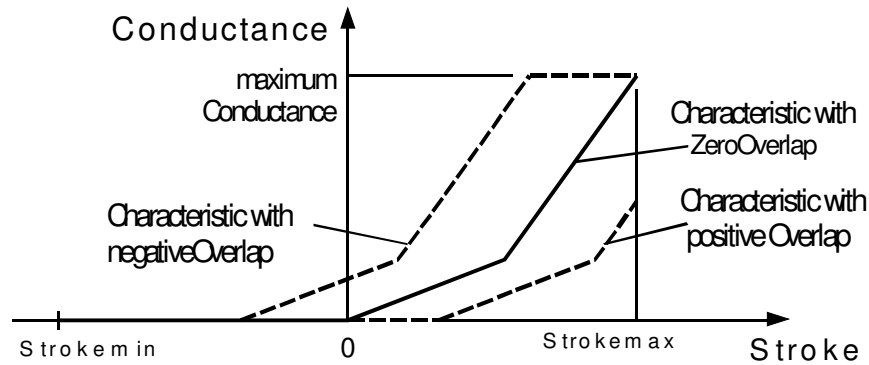
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve

Name	Value	Unit	Description
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE32CHARACTERISTIC is the model of a pneumatic 3/2-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



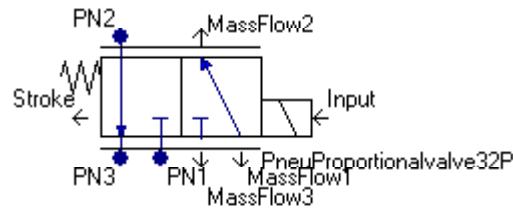
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Stroke_{max}$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Stroke_{min}$. The opening of the valve lasts always $SwitchingTimeOpen$, the closing always $SwitchingTimeClose$. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the $Stroke_{min}$ defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the $Stroke_{min} > Stroke_{max}$, the stroke limits are transferred inside. Both processes are pointed out by message windows.

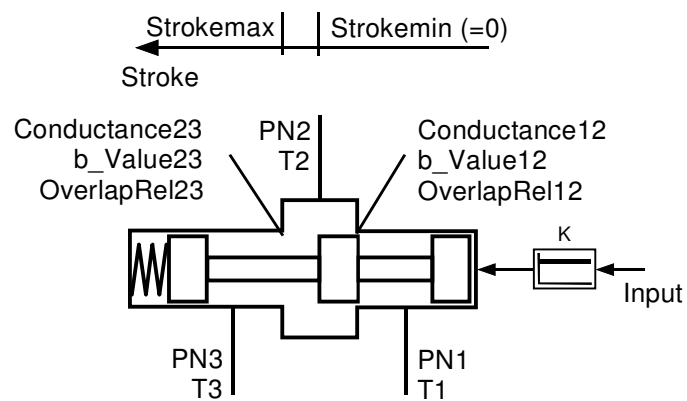
A model of a pneumatic 3/2-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE32).

PneuProportionalvalve32P



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	Input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge between connectors 1 and 2 at <i>Stroke</i> = <i>Strokemin</i> (= 0)
OverlapRel23	0	%	relative overlap of the metering edge between connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between connectors 2 and 3

Notes

The Component PNEUPROPORTIONALVALVE32P is the model of a pneumatic 3/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristics to the metering edges of the valve are defined by conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = \text{Strokemax} / \text{InputMax}$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: metering edge = *Strokemin* opened

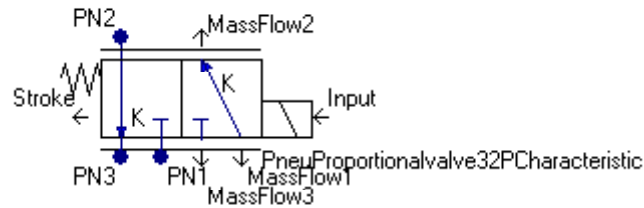
OverlapRel12 = 0: metering edge = *Strokemin* just closed

OverlapRel12 > 0: metering edge = *Strokemin* closed

Take notice about that the *OverlapRel12* is valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* to *Stroke*=*Strokemax*.

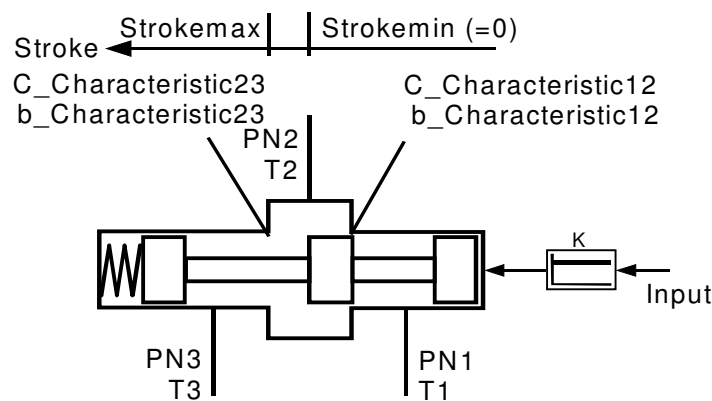
A model of this pneumatic 3/2-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristic of the metering edge is defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32PCCHARACTERISTIC).

PneuProportionalvalve32PCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	Bar	working pressure
PN3	Pneu	Bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	Mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

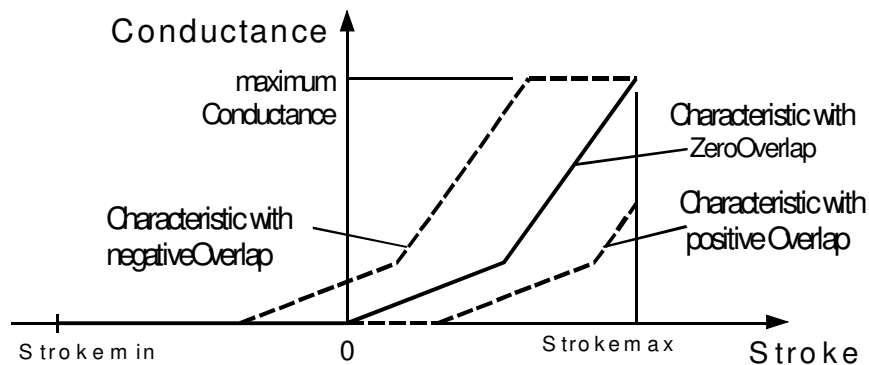
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>

Notes

The component PNEUPROPORTIONALVALVE32PCHARACTERISTIC is the model of a pneumatic 3/2-directional proportional valve. The spool stroke is proportional without any delay to the input signal.

The flow characteristics of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, stroke limits are transferred inside. Both processes are pointed out by message windows.

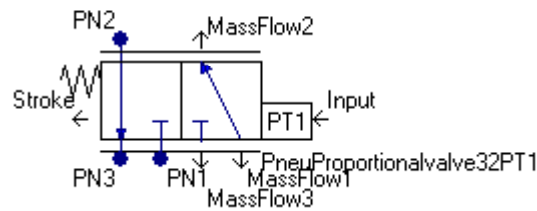
The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = \text{Strokemax}/\text{InputMax}$$

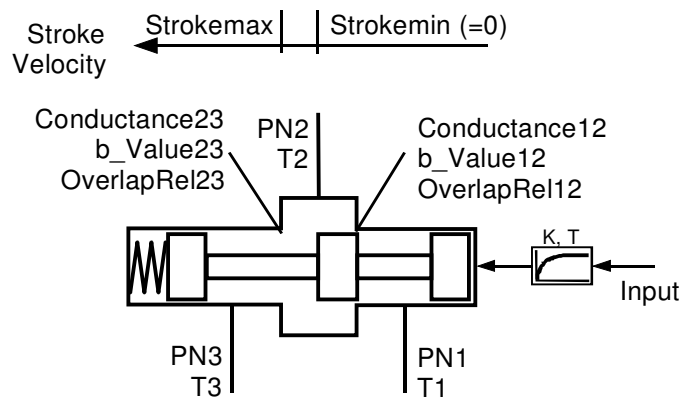
A model of the pneumatic 3/2-directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristics of the metering edges are named by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32P).

PneuProportionalvalve32PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	Kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge between connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between connectors 2 and 3
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The Component PNEUPROPORTIONALVALVE32PT1 is the model of a pneumatic 3/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor K and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$\text{Velocity} = (K \cdot \text{Input} - \text{Stroke}) / \text{TimeConstant}$$

with $K = \text{Strokemax} / \text{InputMax}$.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: metering edge opened

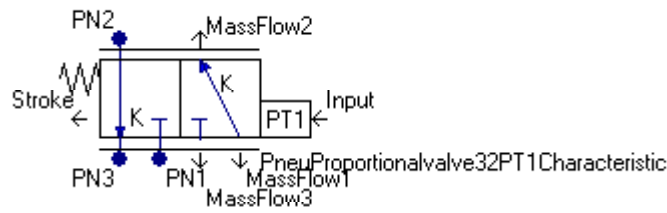
OverlapRel12 = 0: metering edge just closed

OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* is valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* to *Stroke*=*Strokemax*.

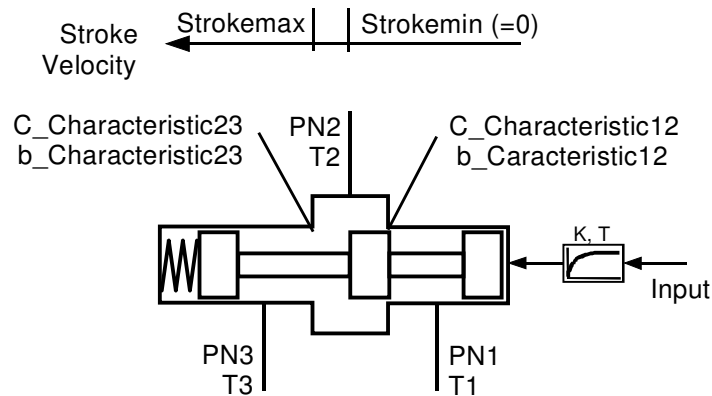
A model of this pneumatic 3/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32PT1CHARACTERISTIC).

PneuProportionalvalve32PT1Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

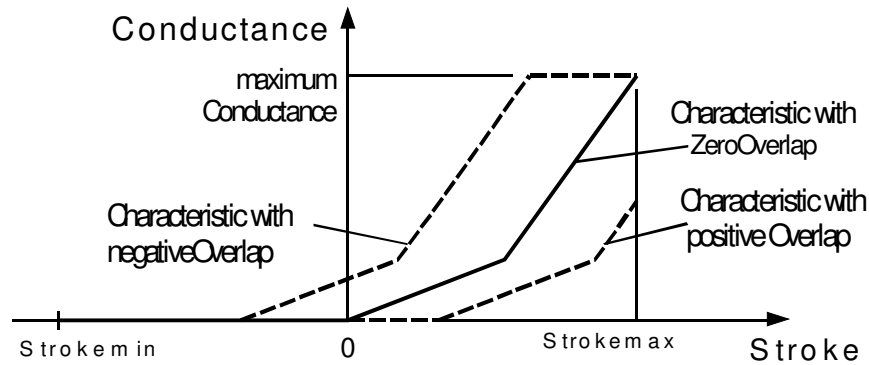
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The Component PNEUPROPORTIONALVALVE32PT1CHARACTERISTIC is the model of a pneumatic 3/2-directional proportional valve. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the valve are defined by look-up tables to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by look up tables. The following figure defines examples of look-up tables of the conductance at zero Overlap, at positive and at negative Overlap of the metering edge:



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

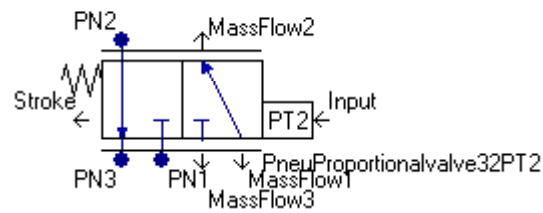
The control characteristic of the valve with PT_1 -behavior is determined by *TimeConstant* and proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Velocity} = (K \cdot \text{Input} - \text{Stroke}) / \text{TimeConstant}$$

with $K = \text{Strokemax} / \text{InputMax}$.

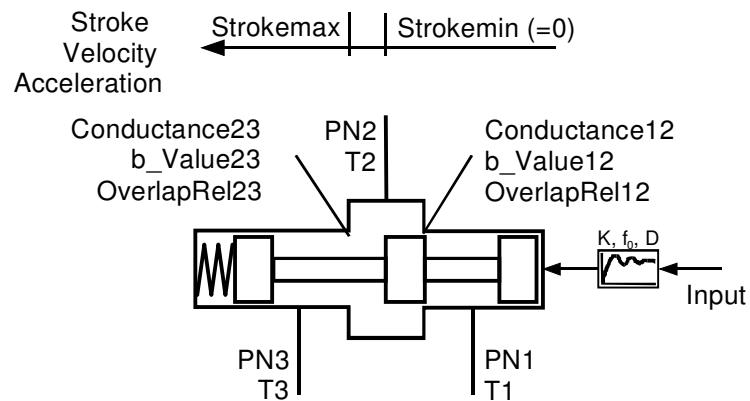
A model of this pneumatic 3/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32PT1).

PneuProportionalvalve32PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE32PT2 is the model of a pneumatic 3/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and Proportional factor K between the *Input* and the *Stroke* of the spool:

$$\begin{aligned} \text{Acceleration} = & K \quad (2\pi \quad \text{EigenFrequency})^2 \quad \text{Input} \\ & - 2 \quad \text{Damping} \quad (2\pi \quad \text{EigenFrequency}) \quad \text{Velocity} \\ & - (2\pi \text{EigenFrequency})^2 \text{Stroke} \end{aligned}$$

with $K = \text{Strokemax}/\text{InputMax}$.

The *Velocity* and the *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

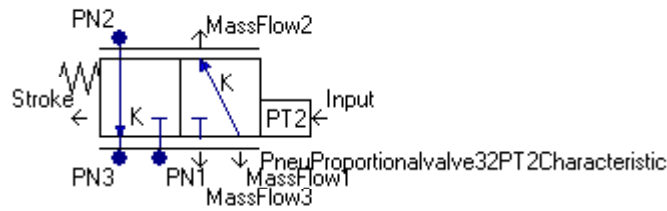
The following rule is effective:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* is valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* to *Stroke*=*Strokemax*.

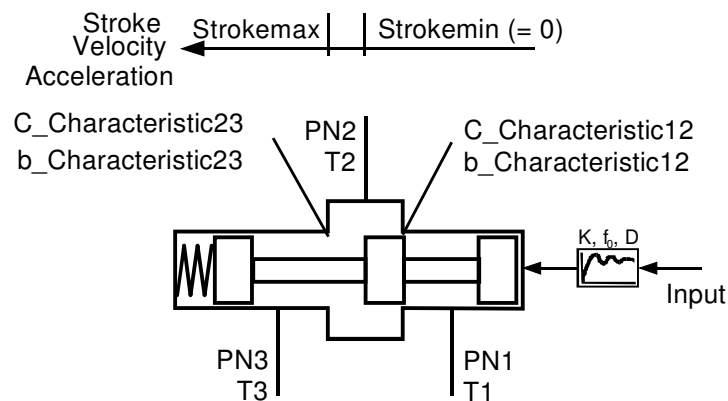
A model of this pneumatic 3/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the second order, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32PT2CHARACTERISTIC).

PneuProportionalvalve32PT2Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	Mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

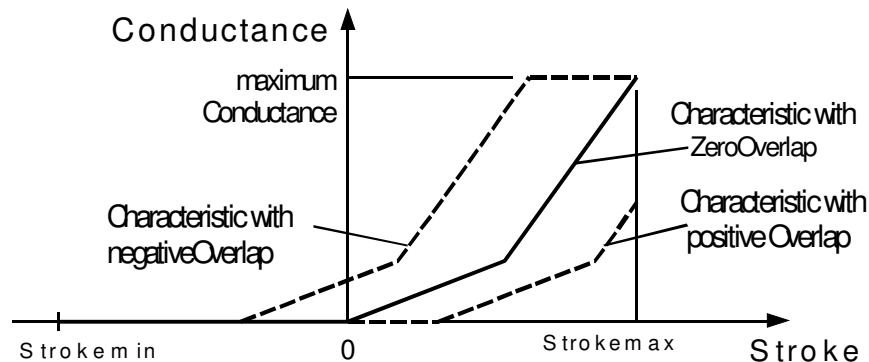
Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the metering edge between the connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table of the conductance of the metering edge between the connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 2 and 3 in dependence of <i>Stroke</i>
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control(D)

Notes

The Component PNEUPROPORTIONALVALVE32PT2CHARACTERISTIC is the model of a pneumatic 3/2- directional proportional valve. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Stroke min* defined with a value unequal zero, stroke limits are automatically displaced to zero. Is the *Stroke min* > *Stroke max*, stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and proportional factor K between the *Input* and the *Stroke* of the spool:

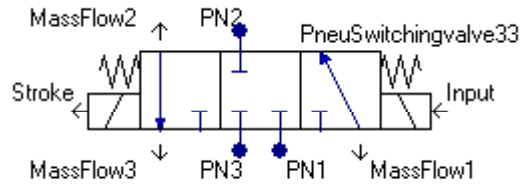
$$\text{Acceleration} = \frac{K}{2 \cdot \text{damping}} \cdot \frac{(2\pi \cdot \text{EigenFrequency})^2}{(2\pi \cdot \text{EigenFrequency})} \cdot \frac{\text{Input}}{\text{Velocity}} - (2\pi \cdot \text{EigenFrequency})^2 \cdot \text{Stroke}$$

with $K = \text{Stroke max} / \text{Input Max}$.

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocity max* und *Velocity min*

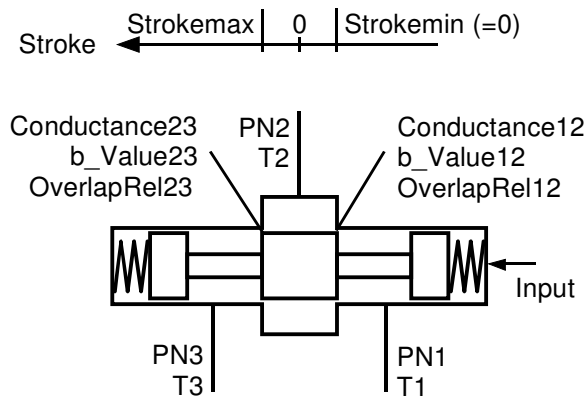
A model of the pneumatic 3/2-directional proportional valve, which's spool stroke is proportional to the input signal with a delay of the second order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE32PT2).

PneuSwitchingvalve33



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve

Name	Value	Unit	Description
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
OverlapRel12	0	%	relative Overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative Overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3

Notes

The component PNEUSWITCHINGVALVE33 is the model of a pneumatic 3/3-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristics of the valve are defined by parameters to conductance's and critical pressure ratios

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke* = *Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke* = *Strokemin*. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The

switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: metering edge in normal position opened

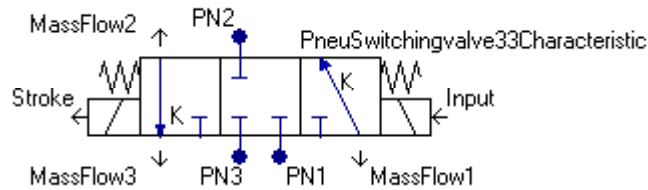
OverlapRel12 = 0: metering edge in normal position just closed

OverlapRel12 > 0: metering edge in normal position closed

Take notice about that the *OverlapRel12* is valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* to *Stroke*=*Strokemax*.

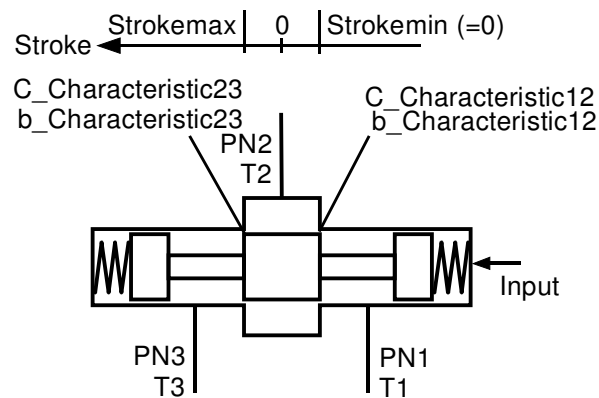
A model of a pneumatic 3/3-directional switching valve is available as a component, which's flow characteristics of the metering edge are defined by look-up tables to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE33CHARACTERISTIC).

PneuSwitchingvalve33Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

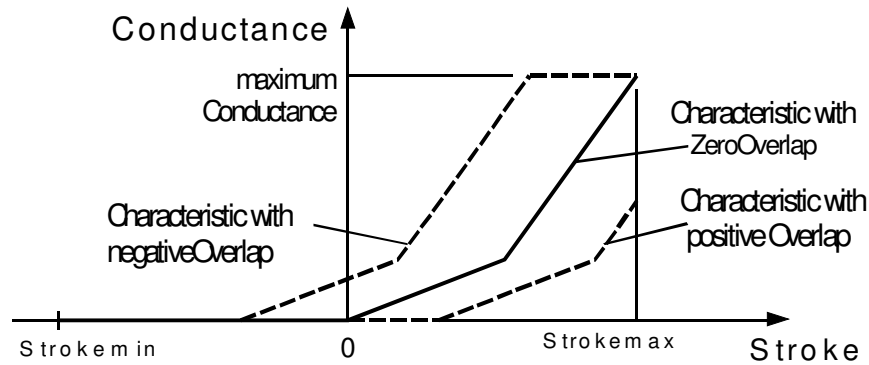
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve

Name	Value	Unit	Description
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 und 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 und 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 und 3 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE33CHARACTERISTIC is the model of a pneumatic 3/3-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



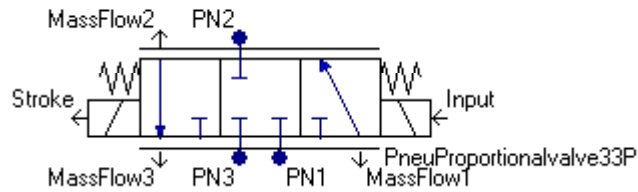
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin$. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the $Strokemin > Strokemax$, the stroke limits are transferred inside. Both processes are pointed out by message windows.

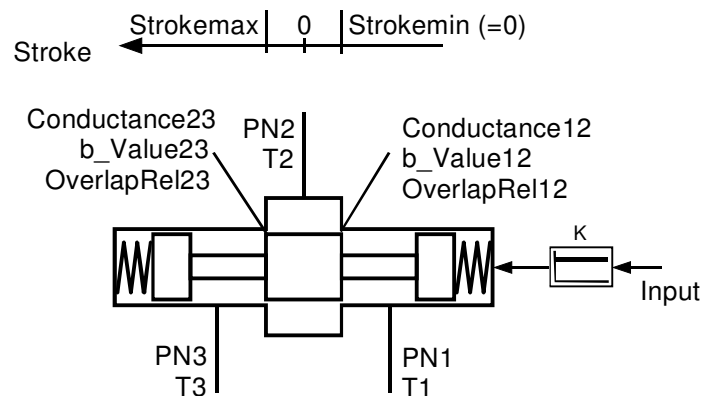
A model of a pneumatic 3/3-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE33).

PneuProportionalvalve33P



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	-1	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke</i> = <i>Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3

Notes

The component PNEUPROPORTIONALVALVE33P is the model of a pneumatic 3/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristics to the metering edges of the valve are defined by conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = (I\text{Strokemax}/I\text{InputMaxI}, I\text{Strokemin}/I\text{InputMinI})$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

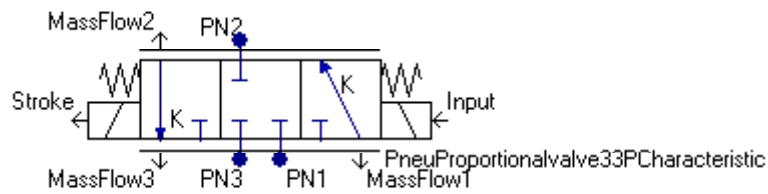
OverlapRel12 < 0: metering edge in normal position opened

OverlapRel12 = 0: metering edge in normal position just closed

OverlapRel12 > 0: metering edge in normal position closed

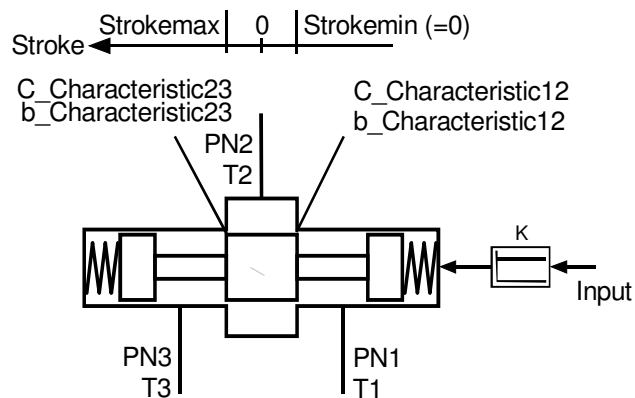
A model of this pneumatic 3/3-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33PCCHARACTERISTIC).

PneuProportionalvalve33PCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

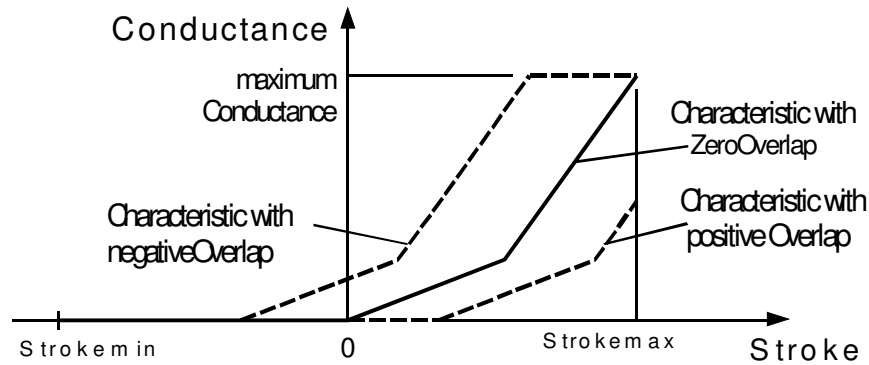
Name	Value	Unit	Description
Strokemax	1	Mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	-1	Mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke</i> = <i>Strokemin</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 und 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 und 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 und 3 in dependence of <i>Stroke</i>

Notes

The Component PNEUPROPORTIONALVALVE33PCCHARACTERISTIC is the model of a pneumatic 3/3-directional proportional valve. The spool stroke is proportional without any delay to the input signal.

The flow characteristics of the metering edges of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, stroke limits are transferred inside. Both processes are pointed out by message windows.

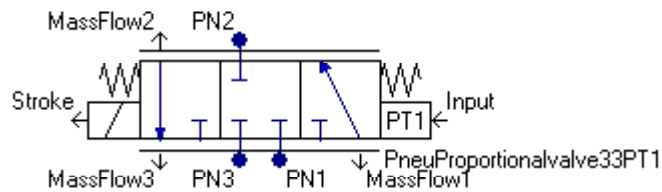
The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$$

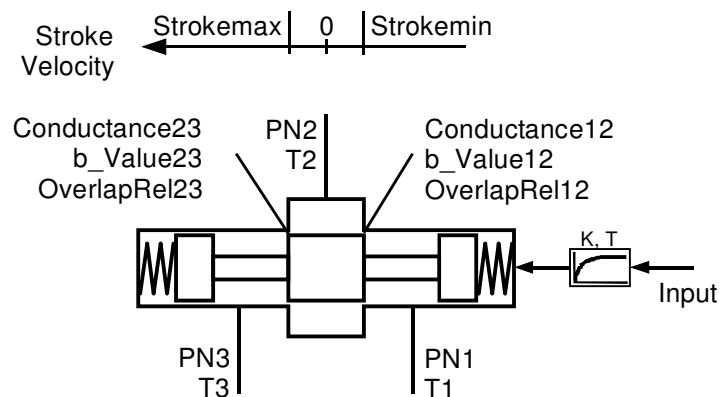
A model of the pneumatic 3/3-directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristics of the metering edges are named by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33P).

PneuProportionalvalve33PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke</i> = <i>Strokemin</i>
OverlapRel12	0	%	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
OverlapRel23	0	%	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
PolytropicExponent	1.4	-	polytropic exponent of the gas
Conductance12	1	NI/s/bar	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
Conductance23	1	NI/s/bar	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Value12	0.528	-	critical pressure ratio to the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio to the flow between the connectors 2 and 3
TimeConstant	10	ms	parameter to the control characteristic (T)

Notes

The component PNEUPROPORTIONALVALVE33PT1 is the model of a pneumatic 3/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor K and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = \max(|Stroke_{max}/Input_{Max}|, |Stroke_{min}/Input_{Min}|).$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

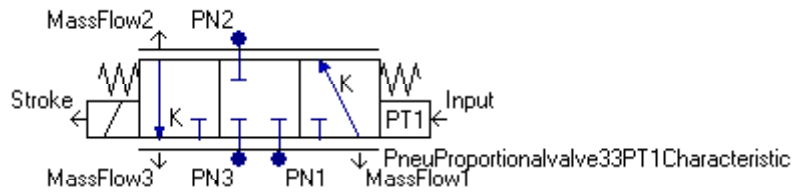
OverlapRel12 < 0: metering edge in normal position opened

OverlapRel12 = 0: metering edge in normal position just closed

OverlapRel12 > 0: metering edge in normal position closed

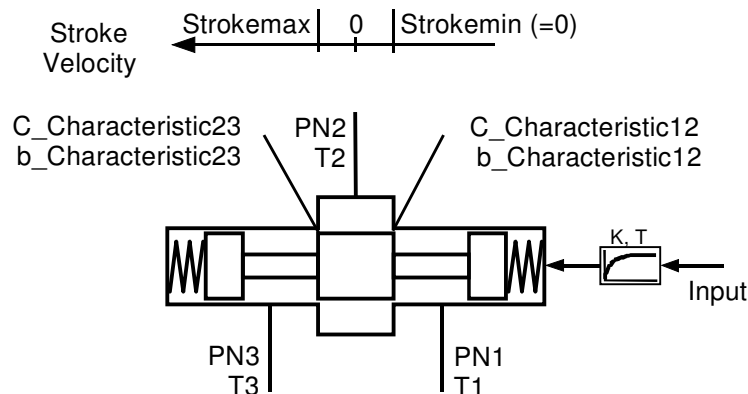
A model of this pneumatic 3/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33PT1CHARACTERISTIC).

PneuProportionalvalve33PT1Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Parameters

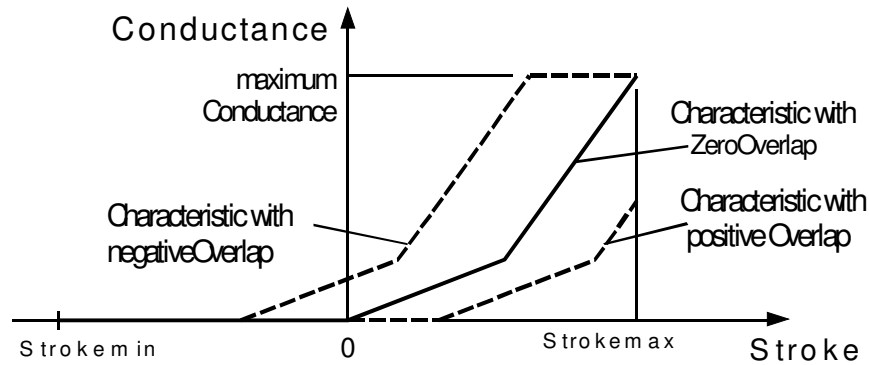
Name	Value	Unit	Description
Strokemax	1	Mm	maximum spool stroke in positive direction

Name	Value	Unit	Description
Strokemin	-1	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke</i> = <i>Strokemin</i>
Polytropic exponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 und 2 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 und 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 und 3 in dependence of <i>Stroke</i>
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The Component PNEUPROPORTIONALVALVE33PT1CHARACTERISTIC is the model of a pneumatic 3/3-directional proportional valve. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by look-up tables to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by look up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

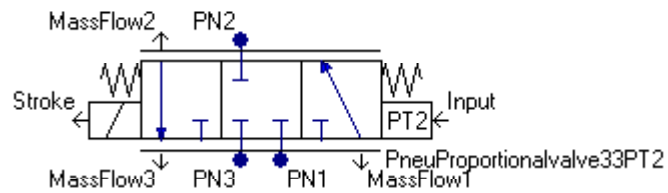
The control characteristic of the valve with PT_1 -behavior is determined by *TimeConstant* and proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = \max(|Strokemax/InputMax|, |Strokemin/InputMin|).$$

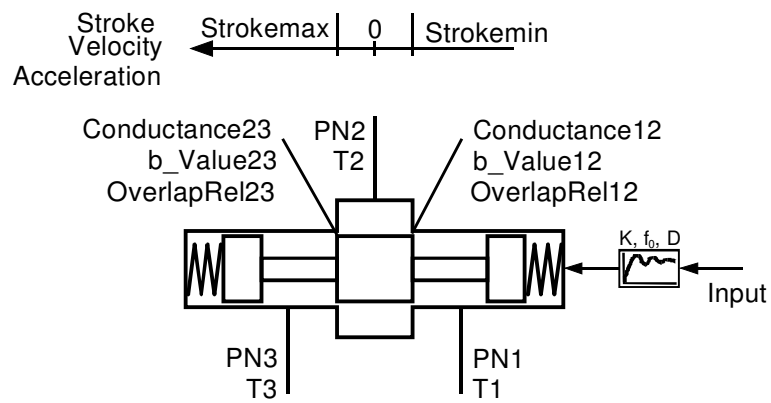
A model of this pneumatic 3/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33PT1).

PneuProportionalvalve33PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	Kg/s	mass flow in connector 3

Parameters

Name	Value	Unit	Description
Strokemax	1	Mm	maximum spool stroke in positive direction
Strokemin	-1	Mm	minimum spool stroke in negative direction
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at normal position of the spool
OverlapRel23	0	%	Relative overlap of the metering edge between the connectors 2 und 3 at normal position of the spool
Polytropic exponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control(D)

Notes

The component PNEUPROPORTIONALVALVE33PT2 is the model of a pneumatic 3/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* *D* and Proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2} \frac{(2\pi \text{EigenFrequency})^2}{\text{Damping}} \frac{\text{Input}}{(2\pi \text{EigenFrequency})^2 \text{Stroke} - \text{Velocity}}$$

with $K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$.

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*.

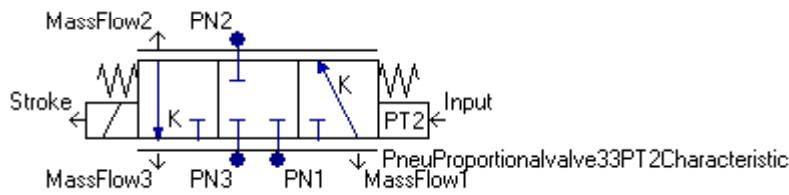
The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel12 < 0: metering edge in normal position opened
OverlapRel12 = 0: metering edge in normal position just closed
OverlapRel12 > 0: metering edge in normal position closed

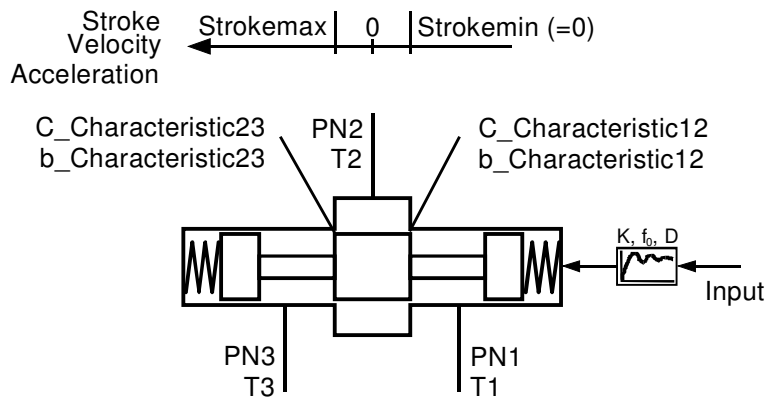
A model of this pneumatic 3/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the second order, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33PT2CHARACTERISTIC).

PneuProportionalvalve33PT2Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure
PN3	Pneu	bar	ventilation
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

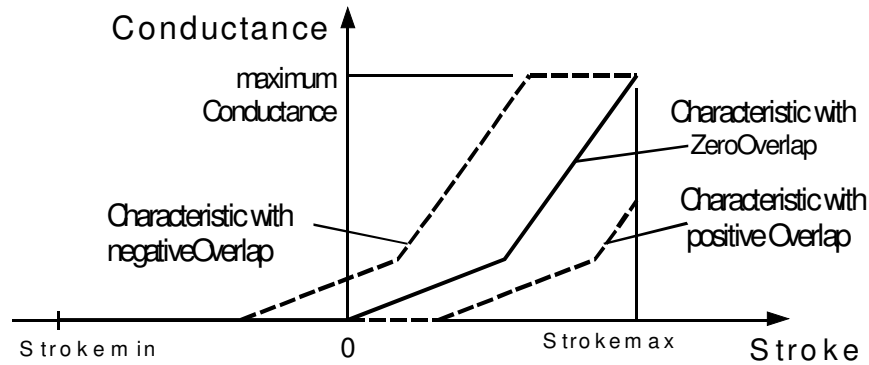
Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at $Stroke = Strokemax$
InputMin	-1	-	input signal at $Stroke = Strokemin$
Polytropic exponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of $Stroke$
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of $Stroke$
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of $Stroke$
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of $Stroke$
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE33PT2CHARACTERISTIC is the model of a pneumatic 3/3-directional proportional valve. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Stroke min* > *Stroke max*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2 \cdot \text{damping}} \cdot \frac{(2\pi \cdot \text{EigenFrequency})^2}{(2\pi \cdot \text{EigenFrequency})^2} \cdot \frac{\text{Input}}{\text{Velocity}} - (2\pi \cdot \text{EigenFrequency})^2 \cdot \text{Stroke}$$

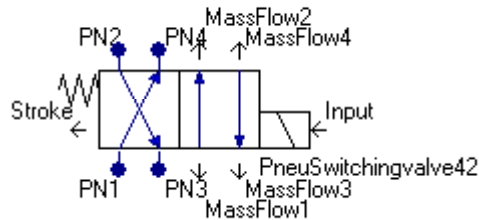
$$\text{with } K = . = \max(|\text{Stroke max}/\text{InputMax}|, |\text{Stroke min}/\text{InputMin}|)$$

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocity max* und *Velocity min*

A model of the pneumatic 3/3-directional proportional valve, which's spool stroke is proportional to the input signal with a delay of the second order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE33PT2).

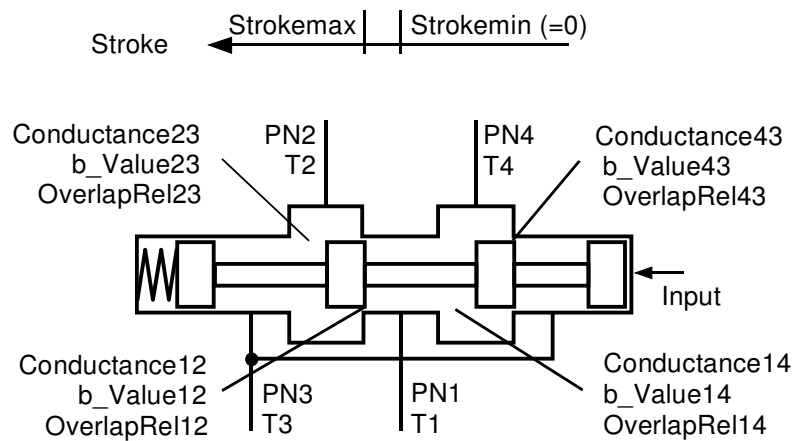
4-x-Valves

PneuSwitchingvalve42



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 and 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemax</i>

Name	Value	Unit	Description
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3

Notes

The component PNEUSWITCHINGVALVE42 is the model of a pneumatic 4/2-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke = Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke = Strokemin*. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

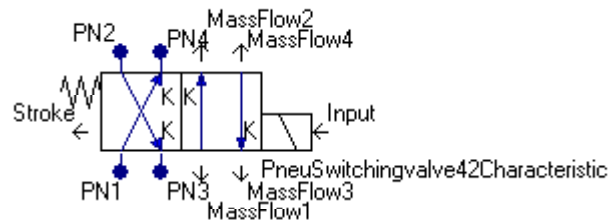
The following rule is effective:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that *OverlapRel12* and *OverlapRel43* are valid to *Stroke = Strokemin* = 0 and the *OverlapRel23* and *OverlapRel14* to *Stroke=Strokemax*.

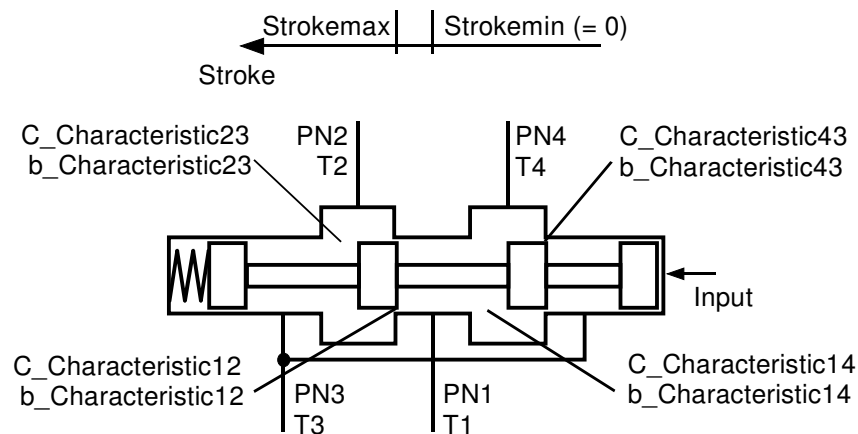
A model of a pneumatic 4/2-directional switching valve is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE42CHARACTERISTIC).

PneuSwitchingvalve42Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

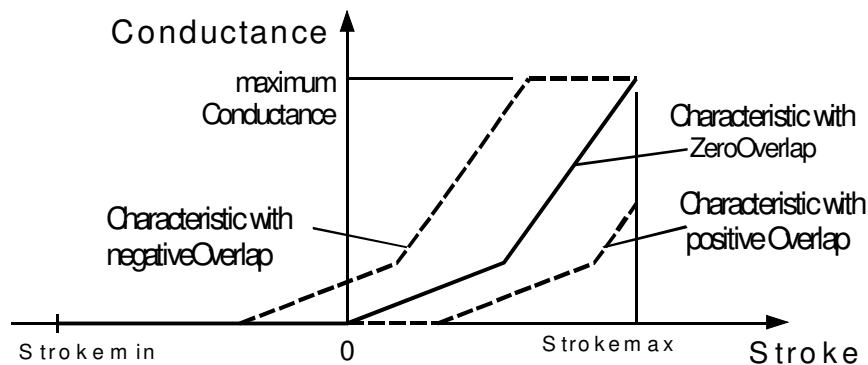
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Polytropic exponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the metering edge between the connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table of the conductance of the metering edge between the connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table of the conductance of the metering edge between the connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table of the conductance of the metering edge between the connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 1 and 4 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic23	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table of the critical pressure ratio of the flow between the connectors 4 and 3 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE42CHARACTERISTIC is the model of a pneumatic 4/2-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



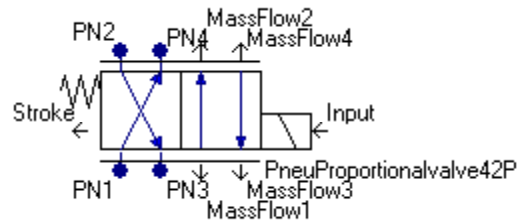
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin (=0)$. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the $Strokemin > Strokemax$, the stroke limits are transferred inside. Both processes are pointed out by message windows.

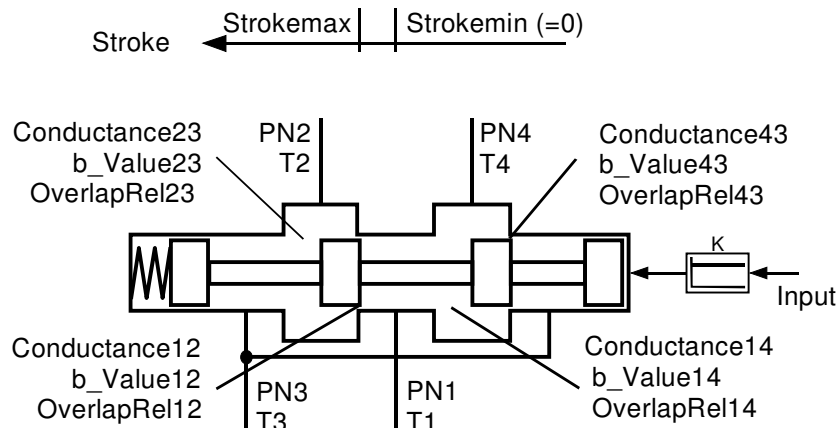
A model of a pneumatic 4/2-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE42).

PneuProportionalvalve42P



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12			relative overlap of the metering edge between the connectors 1 und 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 und 3 at <i>Stroke</i> = <i>Strokemax</i>
Polytropic exponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemin</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemin</i>
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemin</i>

Name	Value	Unit	Description
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 und 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 und 3

Notes

The component PNEUPROPORTIONALVALVE42P is the model of a pneumatic 4/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristics to the metering edges of the valve are defined by conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = \text{Strokemax}/\text{InputMax}$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

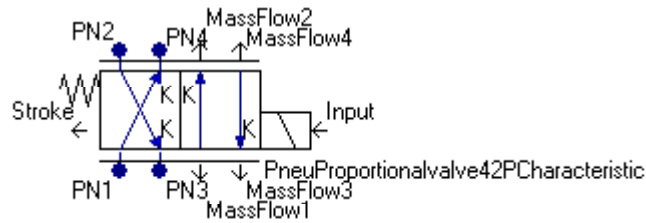
The following rule is effective:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* and the *OverlapRel43* are valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* and the *OverlapRel14* to *Stroke*=*Strokemax*.

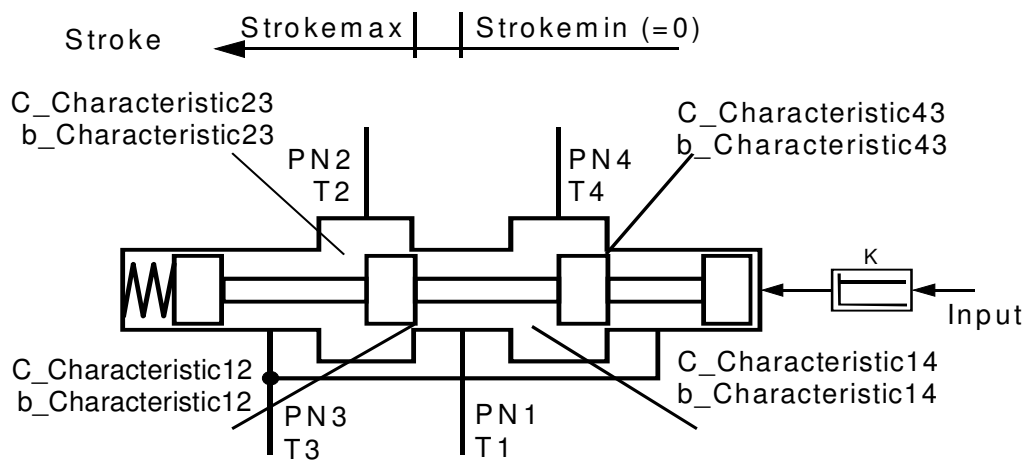
A model of this pneumatic 4/2-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42PCHARACTERISTIC).

PneuProportionalvalve42PCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

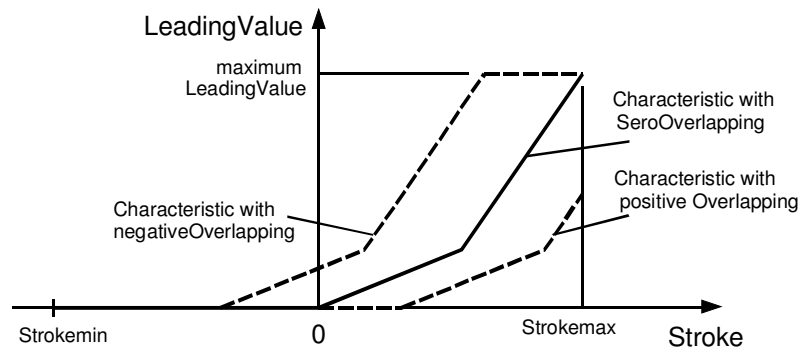
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 und 3 in dependence of <i>Stroke</i>

Notes

The component PNEUPROPORTIONALVALVE42PCHARACTERISTIC is the model of a pneumatic 4/2-directional proportional valve. The spool stroke is proportional without any delay to the input signal.

The flow characteristics of the metering edges of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, stroke limits are transferred inside. Both processes are pointed out by message windows.

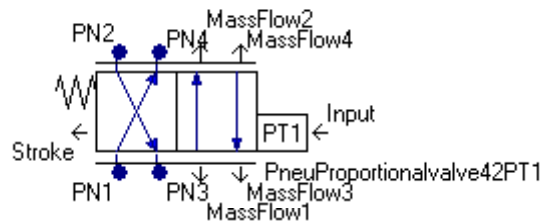
The control characteristic of the valve with P-behaviour is determined by proportional factor K between the *Input* and the *Stroke* of the spool:

$$Stroke = K \cdot Input$$

$$\text{with } K = Strokemax/InputMax$$

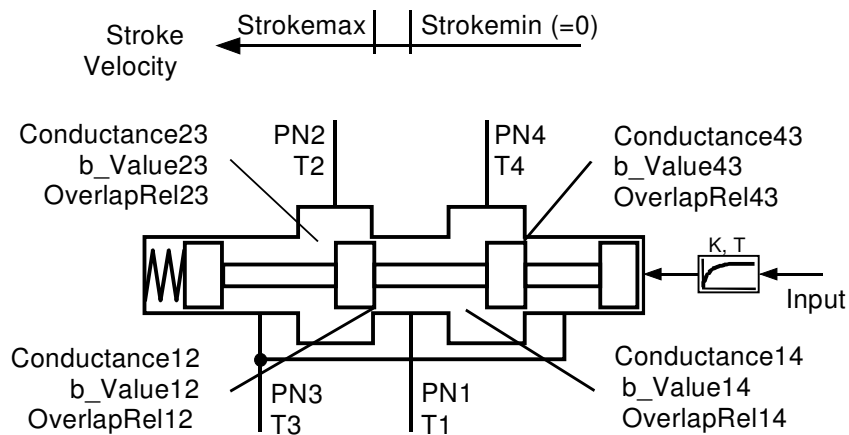
A model of the pneumatic 4/2-directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristics of the metering edges are named by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42P).

PneuProportionalvalve42PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2

Name	Type	Unit	Description
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 und 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 und 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemin</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke</i> = <i>Strokemin</i>

Name	Value	Unit	Description
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 und 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 und 3
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE42PT1 is the model of a pneumatic 4/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor *K* and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$\text{Velocity} = (K \cdot \text{Input} - \text{Stroke}) / \text{TimeConstant}$$

with $K = \text{Strokemax} / \text{InputMax}$.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

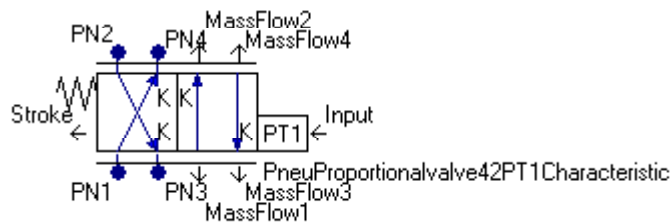
The following rule is effective:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* and the *OverlapRel43* are valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* and the *OverlapRel14* to *Stroke*=*Strokemax*.

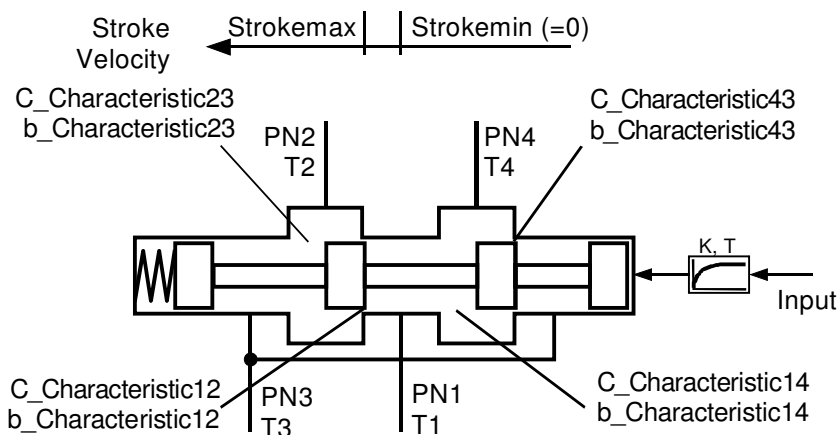
A model of this pneumatic 4/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42PT1CHARACTERISTIC).

PneuProportionalvalve42PT1Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

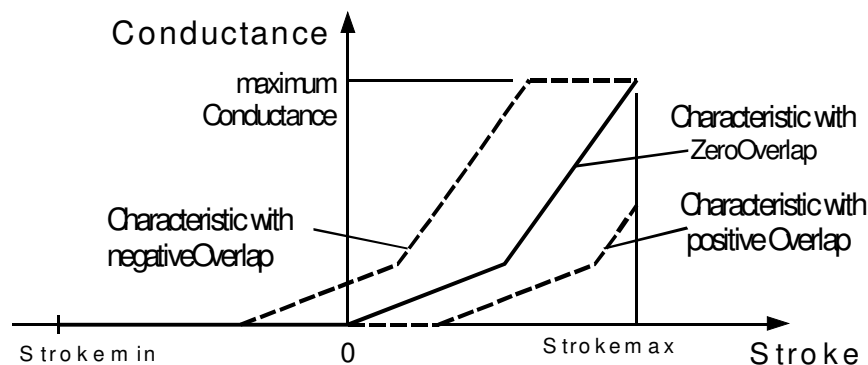
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE42PT1CHARACTERISTIC is the model of a pneumatic 4/2-directional proportional valve. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by look-up tables to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by look up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are transferred inside. Both processes are pointed out by message windows.

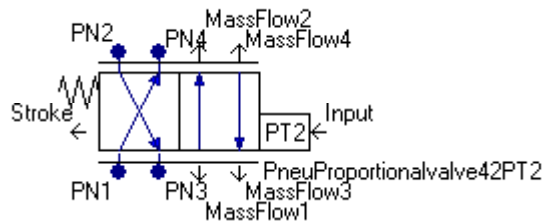
The control characteristic of the valve with PT₁-behavior is determined by *TimeConstant* and proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = Strokemax / InputMax$$

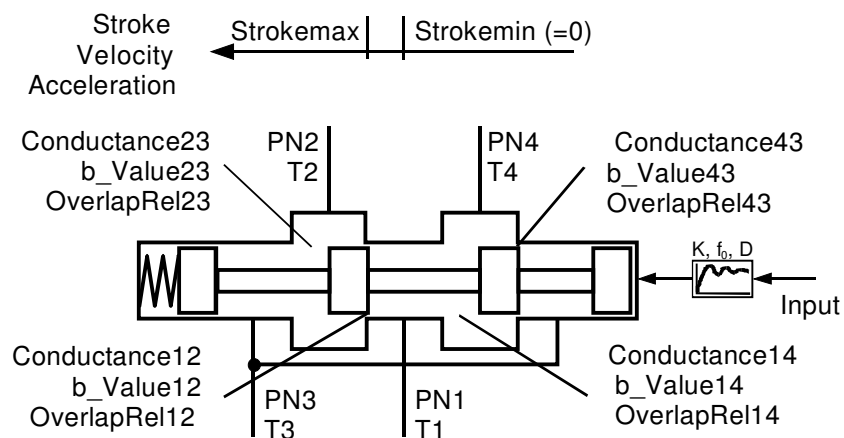
A model of this pneumatic 4/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42PT1).

PneuProportionalvalve42PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in Connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 und 4 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2und 3 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 und 3 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemin</i>

Name	Value	Unit	Description
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemin</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE42PT2 is the model of a pneumatic 4/2-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the stroke limits are automatically displaced. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and Proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2} \frac{(2\pi \text{EigenFrequency})^2}{\text{Damping} (2\pi \text{EigenFrequency}) - (2\pi \text{EigenFrequency})^2 \text{Stroke}} \text{Input Velocity}$$

$$\text{with } K = \text{Strokemax}/\text{InputMax}$$

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

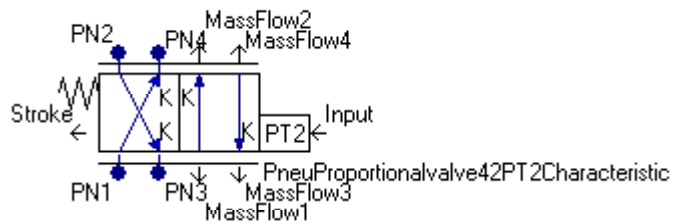
Whereas is valid:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* and the *OverlapRel43* are valid to *Stroke* = *Strokemin* = 0 and the *OverlapRel23* and the *OverlapRel14* to *Stroke*=*Strokemax*.

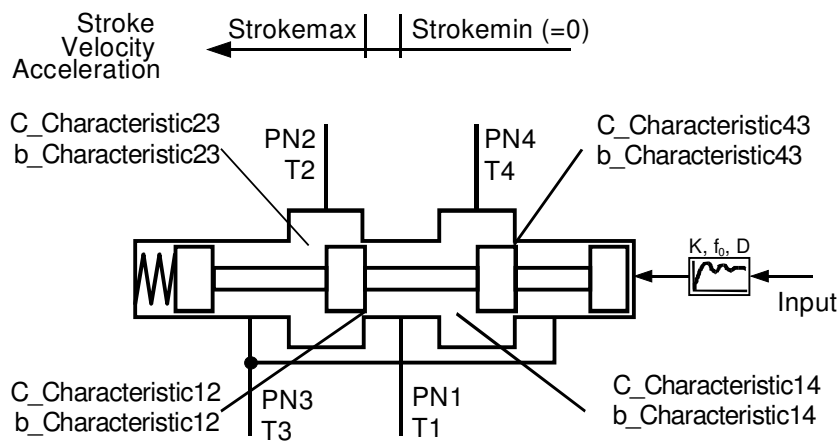
A model of this pneumatic 4/2-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the second order, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42PT2CHARACTERISTIC).

PneuProportionalvalve42PT2Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	Mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2

Name	Type	Unit	Description
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

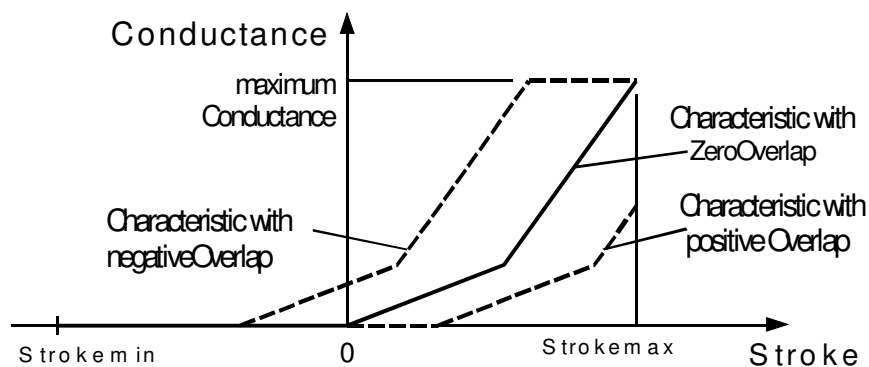
Name	Value	Unit	Description
Strokemax	1	Mm	maximum spool stroke in positive direction
Strokemin	0	Mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE42PT2CHARACTERISTIC is the model of a pneumatic 4/2-directional proportional valve. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Stroke_{min}* defined with a value unequal zero, the stroke limits are automatically displaced to zero. Is the *Stroke_{min}* > *Stroke_{max}*, the stroke limits are automatically displaced. Both processes are pointed out by message windows.

The control characteristic of the valve with PT_2 -behavior is determined by *EigenFrequency* f_0 , *Damping* D and proportional factor K between the *Input* and the *Stroke* of the spool:

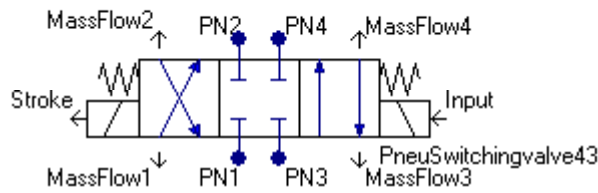
$$\text{Acceleration} = \frac{K}{2 \text{ damping} - (2\pi \text{ EigenFrequency})^2 \text{ Stroke}} (2\pi \text{ EigenFrequency})^2 \text{ Input Velocity}$$

with $K = \dots = \text{Strokemax}/\text{InputMax}$

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*

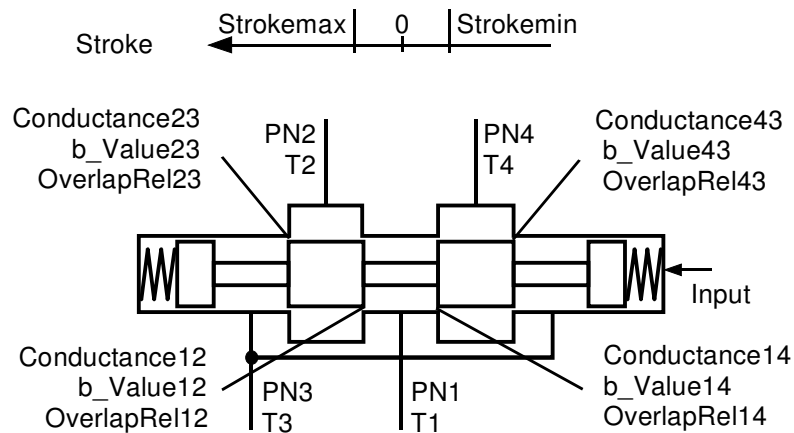
A model of the pneumatic 4/2-directional proportional valve, which's spool stroke is proportional to the input signal with a delay of the second order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE42PT2).

PneuSwitchingvalve43



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameter

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>

Name	Value	Unit	Description
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3

Notes

The component PNEUSWITCHINGVALVE43 is the model of a pneumatic 4/3-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke = Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke = Strokemin*. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

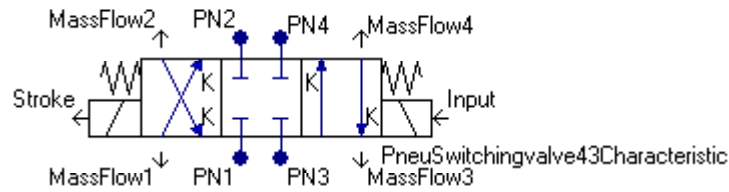
OverlapRel12 < 0: metering edge in normal position opened

OverlapRel12 = 0: metering edge in normal position just closed

OverlapRel12 > 0: metering edge in normal position closed

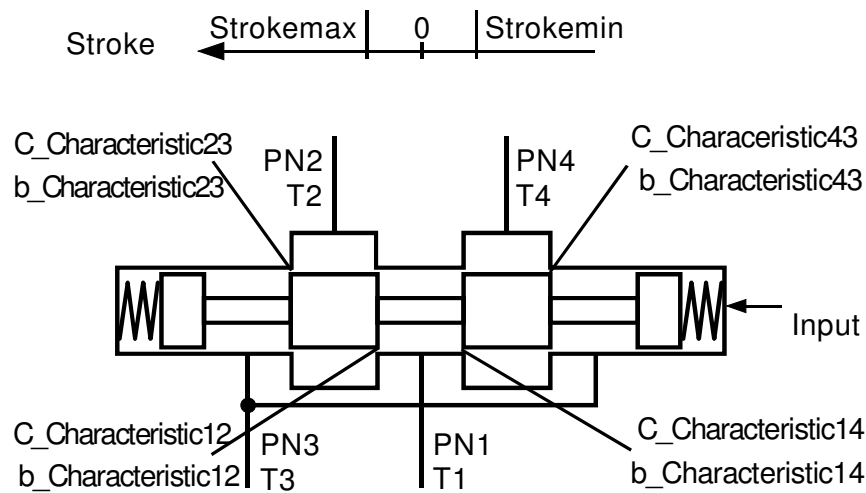
A model of a pneumatic 4/3-directional switching valve is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE43CHARACTERISTIC).

PneuSwitchingvalve43Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

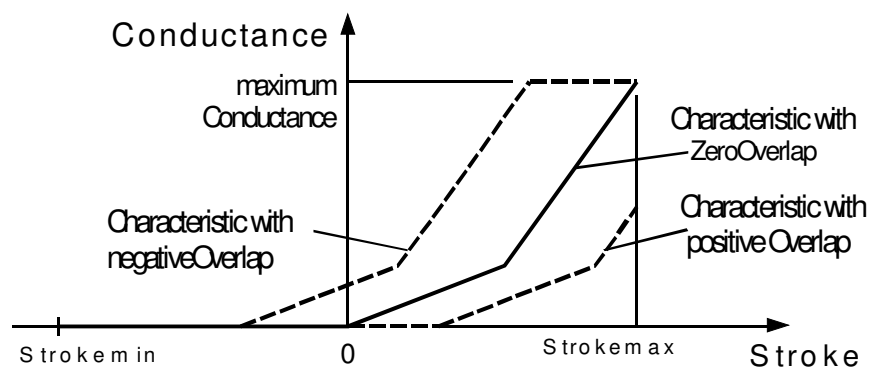
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the metering edge between the connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE43CHARACTERISTIC is the model of a pneumatic 4/3-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



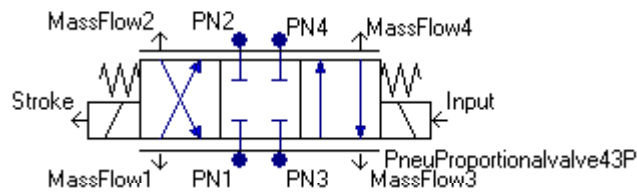
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin$. At $Input (=0)$ the valve switches into normal position. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the $Strokemin > Strokemax$, resp. $InputMin > InputMax$, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

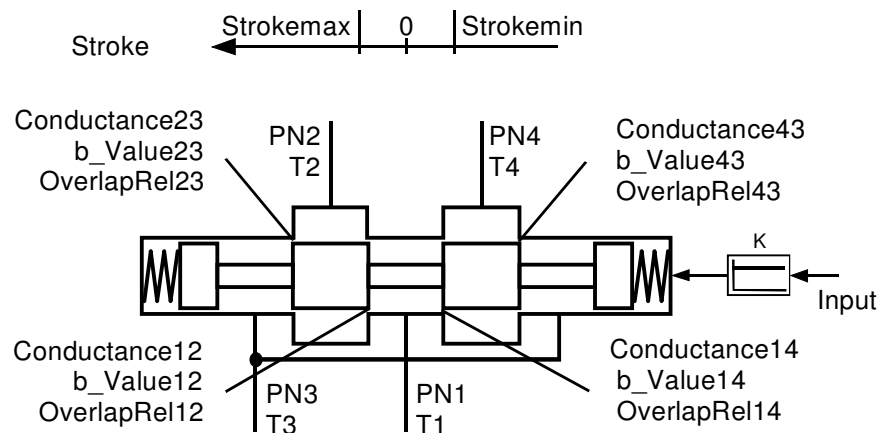
A model of a pneumatic 4/3-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE43).

PneuProportionalvalve43P



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>

Name	Value	Unit	Description
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3

Notes

The component PNEUPROPORTIONALVALVE43P is the model of a pneumatic 4/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristics to the metering edges of the valve are defined by conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor K between the *Input* and the *Stroke* of the spool:

$$Stroke = K \cdot Input$$

$$\text{with } K = \max(|Strokemax/InputMax|, |Strokemin/InputMin|)$$

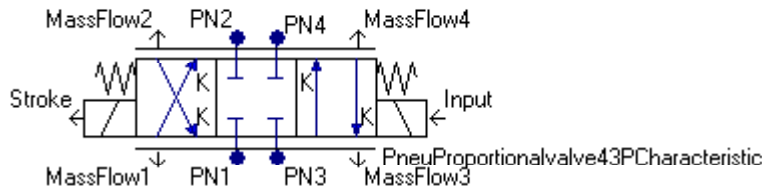
The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

$OverlapRel < 0$: metering edge in normal position open
 $OverlapRel = 0$: metering edge in normal position just closed
 $OverlapRel > 0$: metering edge in normal position closed

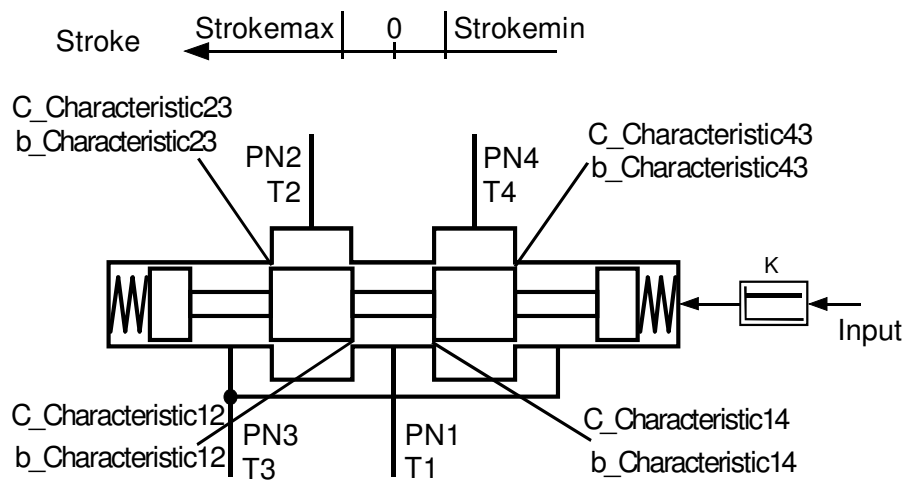
A model of this pneumatic 4/3-directional proportional valve, which's spool stroke is proportional to the input signal, without any delay, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE43PCHARACTERISTIC).

PneuProportionalvalve43PCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

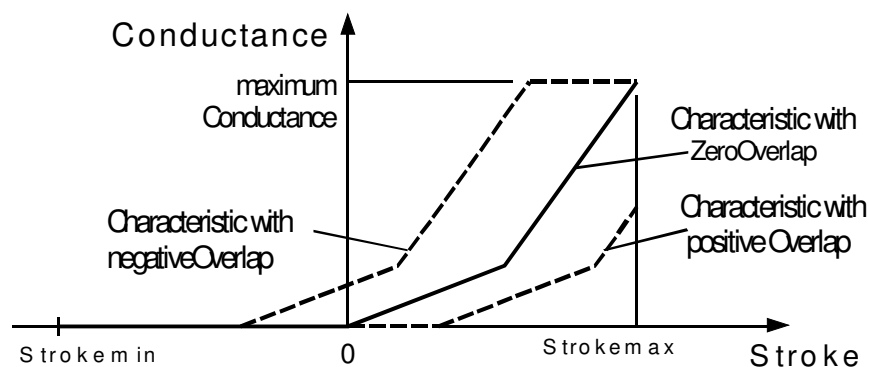
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>

Notes

The component PNEUPROPORTIONALVALVE43PCHARACTERISTIC is the model of a pneumatic 4/3-directional proportional valve. The spool stroke is proportional without any delay to the input signal.

The flow characteristics of the metering edges of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

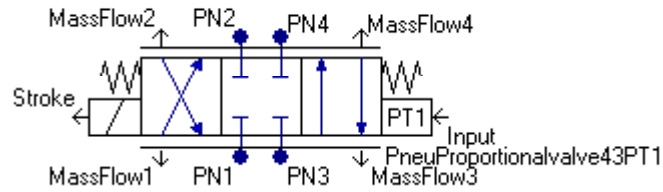
The control characteristic of the valve with P-behaviour is determined by proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$\text{Stroke} = K \cdot \text{Input}$$

$$\text{with } K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$$

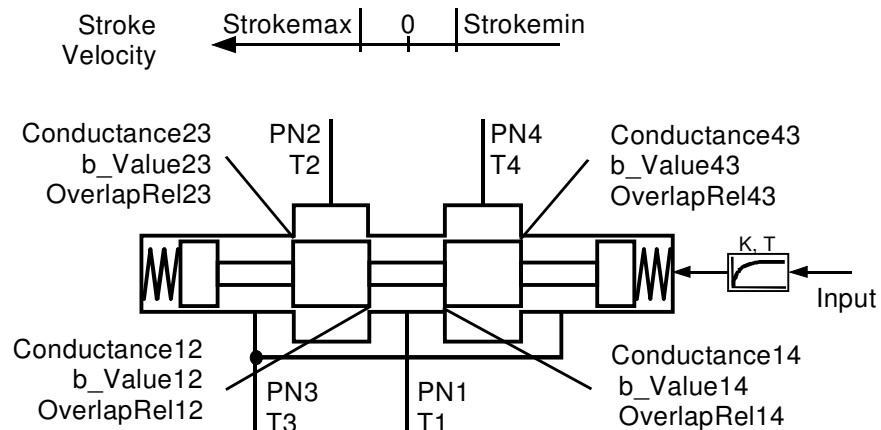
A model of the pneumatic 4/3-directional proportional valve, which's spool stroke is proportional without any delay to the input signal, is available as a component, which's flow characteristics of the metering edges are named by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE43P).

PneuProportionalvalve43PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel43	0	%	relative overlap of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>

Name	Value	Unit	Description
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE43PT1 is the model of a pneumatic 4/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor *K* and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$\text{Velocity} = (K \cdot \text{Input} - \text{Stroke}) / \text{TimeConstant}$$

$$\text{with } K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|).$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

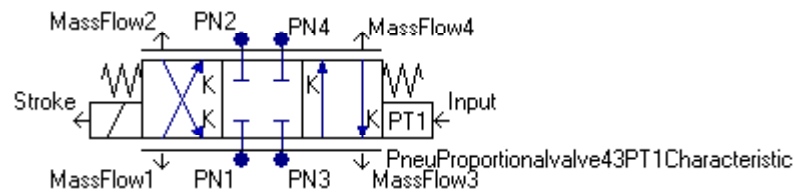
The following rule is effective:

$\text{OverlapRel} < 0$: Metering edge in normal position open
 $\text{OverlapRel} = 0$: Metering edge in normal position just closed
 $\text{OverlapRel} > 0$: Metering edge in normal position closed

A model of this pneumatic 4/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by look-up

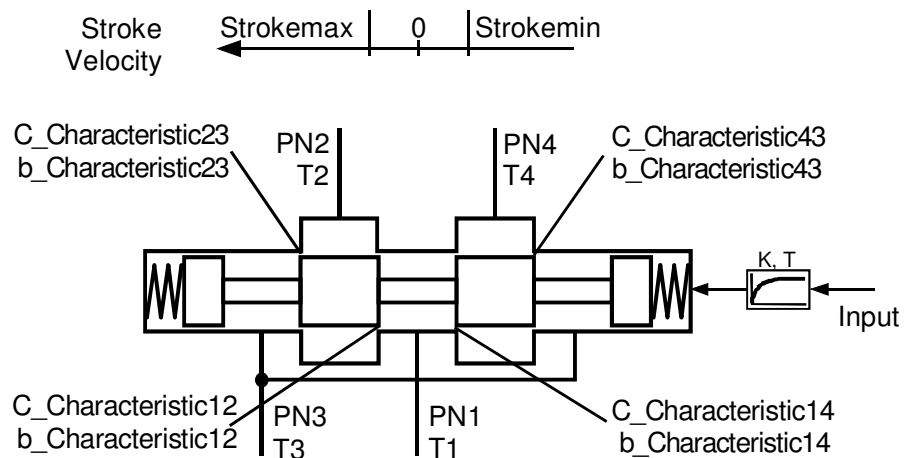
tables to conductance's and critical pressure ratios
(PNEUPROPORTIONALVALVE43PT1CHARACTERISTIC).

PneuProportionalvalve43PT1Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

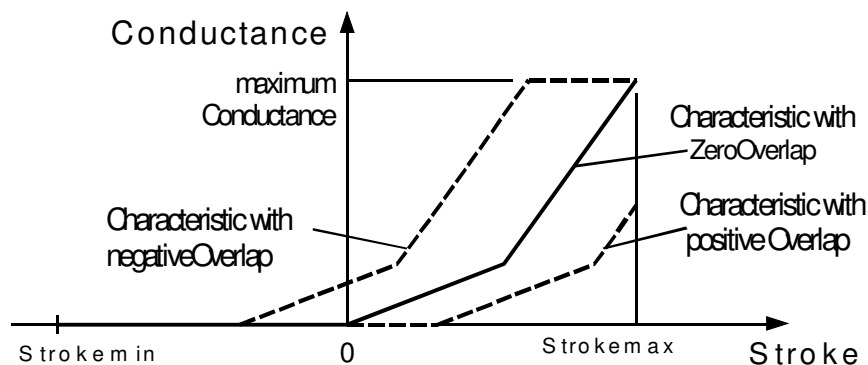
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	Look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE43PT1CHARACTERISTIC is the model of a pneumatic 4/3-directional proportional valve. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by look-up tables to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by look up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the $Strokemin > Strokemax$, resp. $InputMin > InputMax$, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

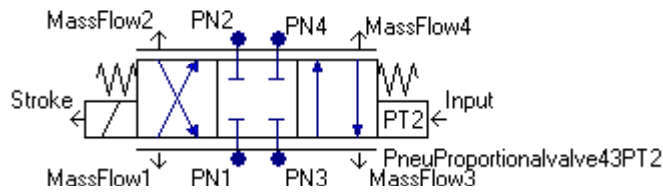
The control characteristic of the valve with PT₁-behavior is determined by *TimeConstant* and proportional factor *K* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

$$\text{with } K = \max(|Strokemax/InputMax|, |Strokemin/InputMin|).$$

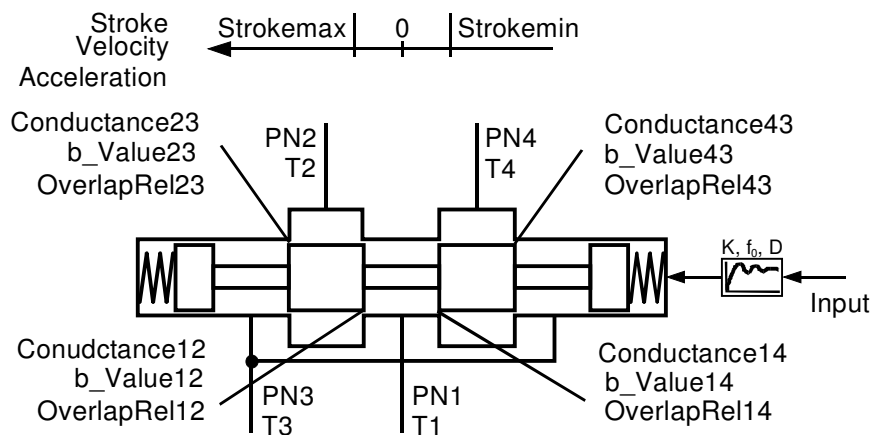
A model of this pneumatic 4/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the first order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE43PT1).

PneuProportionalvalve43PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative Overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative Overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative Overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel43	0	%	relative Overlap of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>

Name	Value	Unit	Description
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
Conductance43	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 3 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value43	0.528	-	critical pressure ratio of the flow between the connectors 4 and 3
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE43PT2 is the model of a pneumatic 4/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and Proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{-2 \text{ Damping} - (2\pi \text{ EigenFrequency})^2 \text{ Stroke}} \left((2\pi \text{ EigenFrequency})^2 \text{ Input Velocity} \right)$$

with $K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$.

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*.

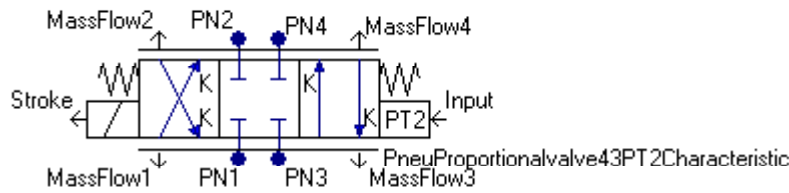
The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel < 0 Metering edge in normal position open
 OverlapRel = 0 Metering edge in normal position just closed
 OverlapRel > 0 Metering edge in normal position closed

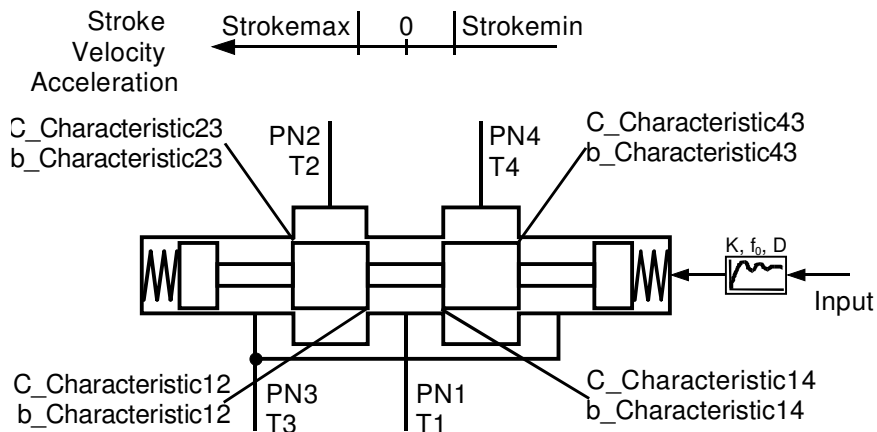
A model of this pneumatic 4/3-directional proportional valve, which's spool stroke is proportional to the input signal, with a delay of the second order, is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE43PT2CHARACTERISTIC).

PneuProportionalvalve43PT2Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation
PN4	Pneu	bar	working pressure 4
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4

Parameters

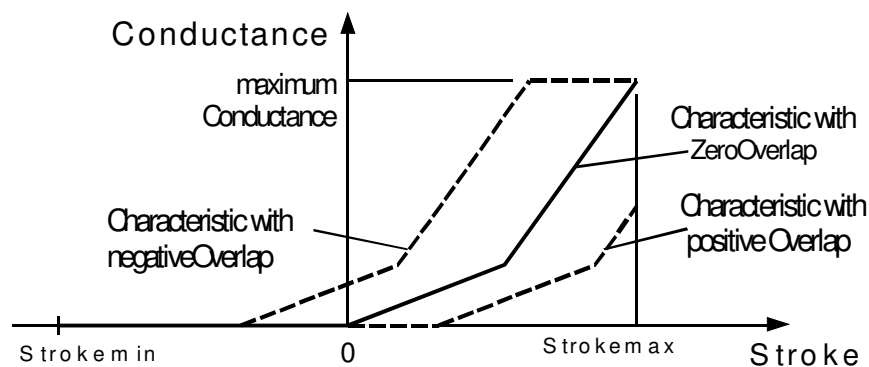
Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at $Stroke = Strokemax$
InputMin	-1	-	input signal at $Stroke = Strokemin$
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table of the conductance of the metering edge between the connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic43	-1	-	look-up table to conductance of the metering edge between connectors 4 and 3 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 2 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 4 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 and 3 in dependence of <i>Stroke</i>
b_Characteristic43	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 and 3 in dependence of <i>Stroke</i>
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE43PT2CHARACTERISTIC is the model of a pneumatic 4/3-directional proportional valve. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the valve are defined by a look-up table to conductance's and critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up table. The following figure defines examples of look-up tables of conductance at zero overlap, at positive and at negative overlap of the metering edge.



The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the $Stroke_{min} > Stroke_{max}$, resp. $InputMin > InputMax$, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT_2 -behavior is determined by *EigenFrequency* f_0 , *Damping* D and proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{2 \cdot \text{damping}} \cdot \frac{(2\pi \cdot \text{EigenFrequency})^2}{(2\pi \cdot \text{EigenFrequency})^2} \cdot \frac{\text{Input}}{\text{Velocity} \cdot \text{Stroke}}$$

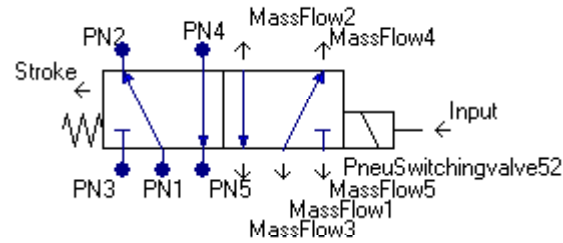
with $K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$..

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*

A model of the pneumatic 4/3-directional proportional valve, which's spool stroke is proportional to the input signal with a delay of the second order, is available as a component, which's flow characteristics of the metering edge are defined by parameters to conductance's and critical pressure ratios (PNEUPROPORTIONALVALVE43PT2).

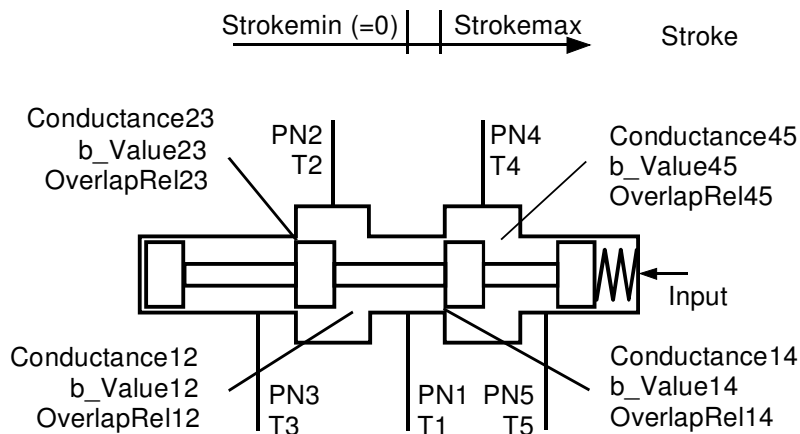
5-x-Valves

PneuSwitchingvalve52



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	Input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1

Name	Type	Unit	Description
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke</i> = <i>Strokemax</i>
OverlapRel45	0	%	relative overlap of the metering edge between the connectors 4 and 5 at <i>Stroke</i> = <i>Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	l/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke</i> = <i>Strokemax</i>

Name	Value	Unit	Description
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
Conductance45	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value45	0.528	-	critical pressure ratio of the flow between the connectors 4 and 5

Notes

The component PNEUSWITCHINGVALVE52 is the model of a pneumatic 5/2-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke = Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke = Strokemin* (=0). The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the strokelimits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the strokelimits are transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

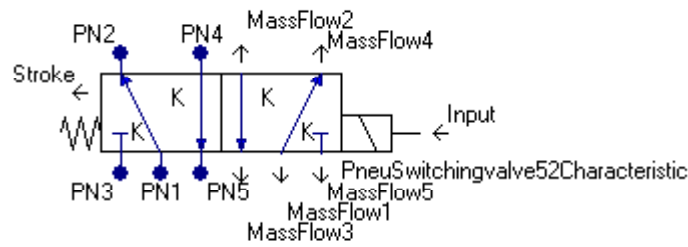
The following rule is effective:

OverlapRel12 < 0: metering edge opened
OverlapRel12 = 0: metering edge just closed
OverlapRel12 > 0: metering edge closed

Take notice about that the *OverlapRel12* and the *OverlapRel45* are valid to *Stroke* = *Strokemax* = 0 and the *OverlapRel23* and the *OverlapRel14* to *Stroke*=*Strokemin*.

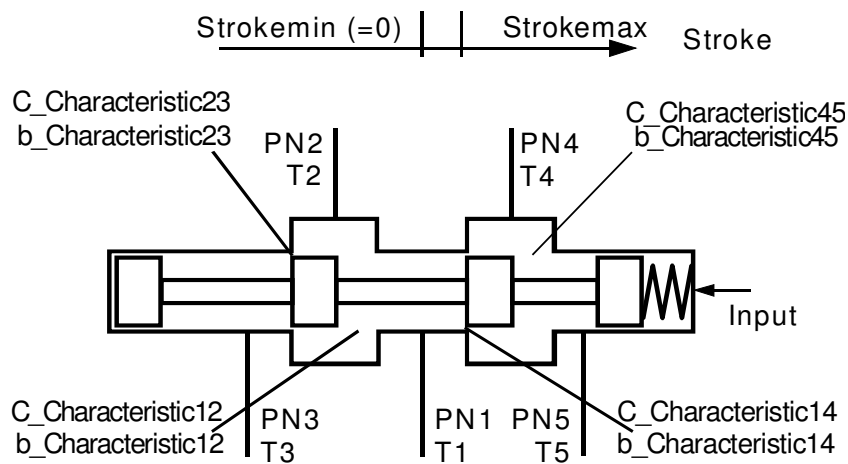
A model of a pneumatic 5/2-directional switching valve is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE52CHARACTERISTIC).

PneuSwitchingvalve52Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2

Name	Type	Unit	Description
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

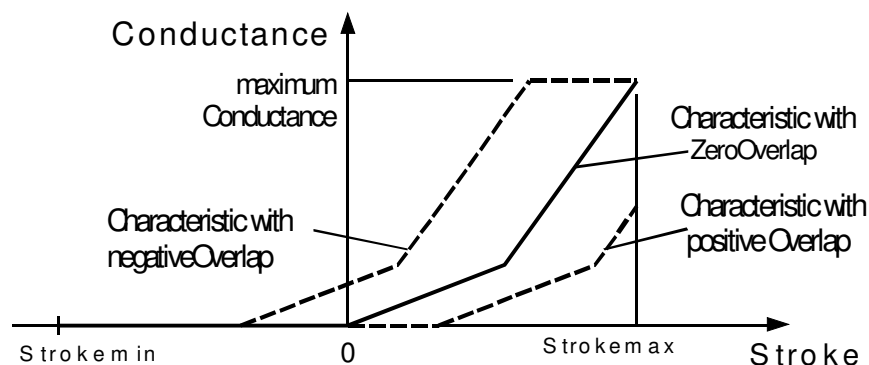
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	0	mm	minimum spool stroke (here each time <i>Strokemin</i> = 0)
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic45	-1	-	look-up table to conductance of the metering edge between connectors 4 and 5 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 4 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 und 3 in dependence of <i>Stroke</i>
b_Characteristic45	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 und 5 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE52CHARACTERISTIC is the model of a pneumatic 5/2-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



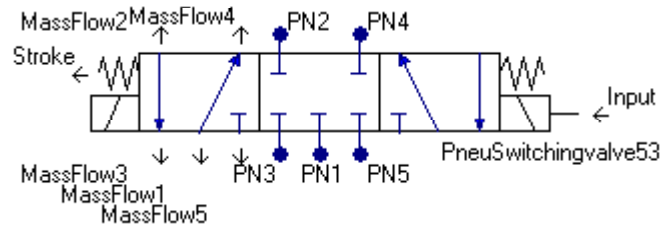
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke* = *Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke* = *Strokemin*. At *Input* (=0) the valve switches into normal position. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* defined with a value unequal zero, the strokelimits are automatically displaced to zero. Is the *Strokemin* > *Strokemax*, the strokelimits are transferred inside. Both processes are pointed out by message windows.

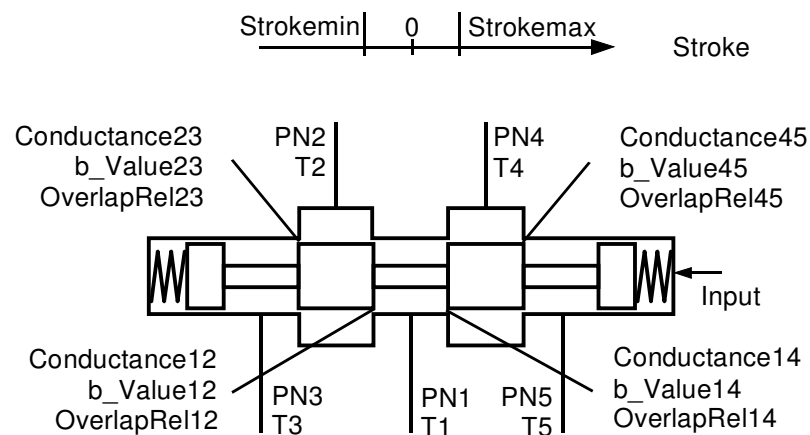
A model of a pneumatic 5/2-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE52).

PneuSwitchingvalve53



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2

Name	Type	Unit	Description
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel45	0	%	relative overlap of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>

Name	Value	Unit	Description
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>
Conductance45	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3
b_Value45	0.528	-	critical pressure ratio of the flow between the connectors 4 and 5

Notes

The component PNEUSWITCHINGVALVE53 is the model of a pneumatic 5/3-directional switching valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For *Input* > 0 the valve switches in positive direction up to *Stroke = Strokemax*, for *Input* ≤ 0 the valve switches in negative direction up to *Stroke = Strokemin* (=0). The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

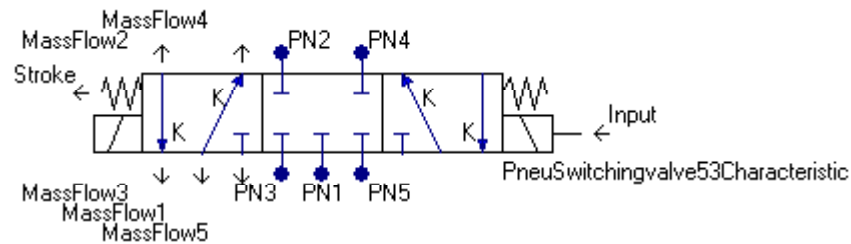
OverlapRel12 < 0: metering edge in normal position opened

OverlapRel12 = 0: metering edge in normal position just closed

OverlapRel12 > 0: metering edge in normal position closed

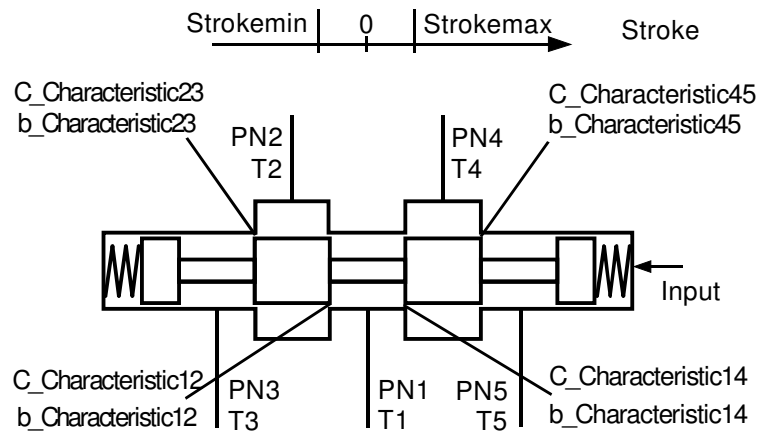
A model of a pneumatic 5/3-directional switching valve is available as a component, which's flow characteristics of the metering edges are defined by look-up tables to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE53CHARACTERISTIC).

PneuSwitchingvalve53Characteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2

Name	Type	Unit	Description
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

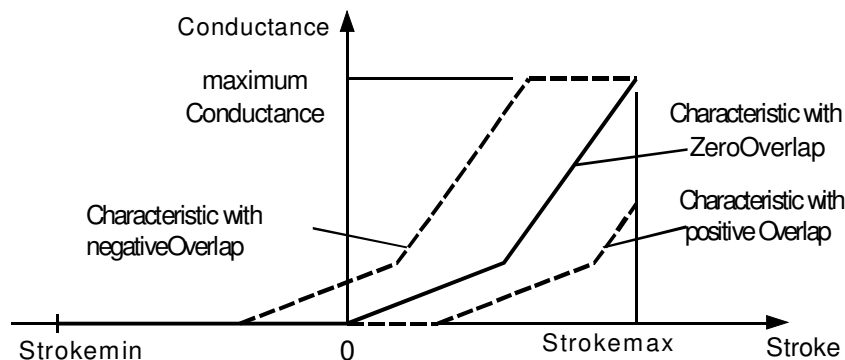
Name	Value	Unit	Description
SwitchingTimeOpen	3	ms	time to open the valve
SwitchingTimeClosed	3	ms	time to close the valve
SwitchingThreshold	0	-	Value of the input signal to open the valve
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
PolytropicExponent	1.4	-	Polytropic exponent of the gas
C_Characteristic12	-1	-	look-up table to conductance of the metering edge between connectors 1 and 2 in dependence of <i>Stroke</i>
C_Characteristic14	-1	-	look-up table to conductance of the metering edge between connectors 1 and 4 in dependence of <i>Stroke</i>
C_Characteristic23	-1	-	look-up table to conductance of the metering edge between the connectors 2 and 3 in dependence of <i>Stroke</i>
C_Characteristic45	-1	-	look-up table to conductance of the metering edge between connectors 4 and 5 in dependence of <i>Stroke</i>
b_Characteristic12	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 and 2 in dependence of <i>Stroke</i>

Name	Value	Unit	Description
b_Characteristic14	-1	-	look-up table to critical pressure ratio of the flow between connectors 1 und 4 in dependence of <i>Stroke</i>
b_Characteristic23	-1	-	look-up table to critical pressure ratio of the flow between connectors 2 und 3 in dependence of <i>Stroke</i>
b_Characteristic45	-1	-	look-up table to critical pressure ratio of the flow between connectors 4 und 5 in dependence of <i>Stroke</i>

Notes

The component PNEUSWITCHINGVALVE53CHARACTERISTIC is the model of a pneumatic 5/3-directional switching valve.

The flow characteristics of the steering wheel edges of the valve are defined by look-up tables to the conductance's and the critical pressure ratios. Overlaps of the metering edges have to be considered by the look-up tables. The following figure defines examples of look-up tables of the conductance at zero overlap, at positive and at negative overlap of the metering edge:



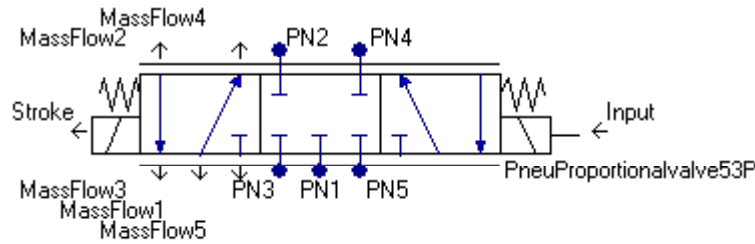
The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

For $Input > 0$ the valve switches in positive direction up to $Stroke = Strokemax$, for $Input \leq 0$ the valve switches in negative direction up to $Stroke = Strokemin$. At $Input (=0)$ the valve switches into normal position. The opening of the valve lasts always *SwitchingTimeOpen*, the closing always *SwitchingTimeClose*. The switching times not only include the real time, the valve spool needs to set by the stroke, they either include the dead resp. responding time of the valve.

Is the $Strokemin > Strokemax$, resp. the $InputMin > InputMax$ the strokelimits and the input signal are transferred inside. Both processes are pointed out by message windows.

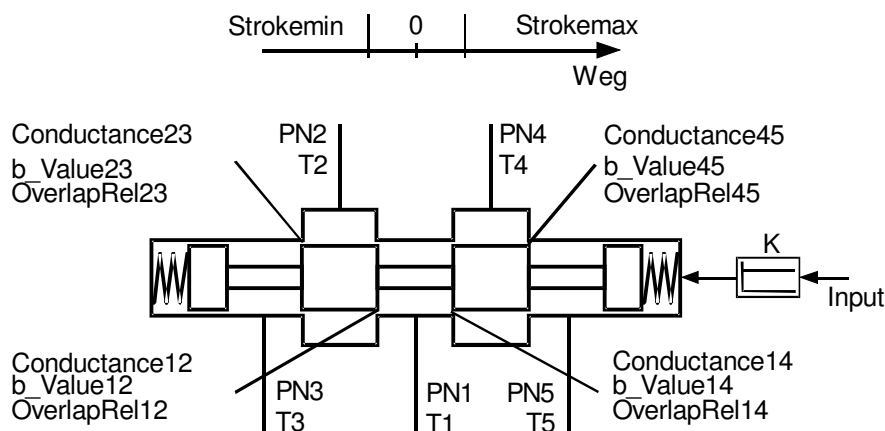
A model of a pneumatic 5/3-directional switching valve is available as a component, which's flow characteristic of the metering edge is defined by parameters to conductance's and critical pressure ratios (PNEUSWITCHINGVALVE53).

PneuProportionalvalve53P



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel45	0	%	relative overlap of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>

Name	Value	Unit	Description
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
Conductance45	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value45	0.528	-	critical pressure ratio of the flow between the connectors 4 and 5

Notes

The component PNEUPROPORTIONALVALVE53P is the model of a pneumatic 5/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional without any delay to the input signal.

The flow characteristics to the metering edges of the valve are defined by conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with P-behaviour is determined by proportional factor K between the *Input* and the *Stroke* of the spool:

$$Stroke = K \cdot Input$$

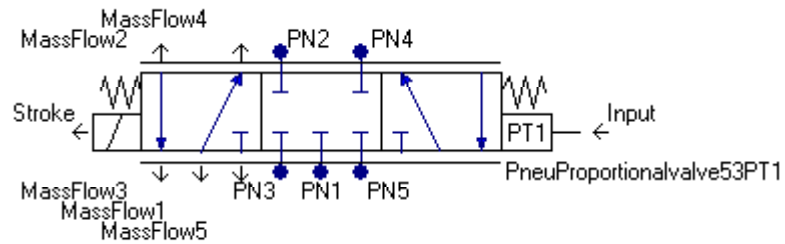
$$\text{with } K = \max(|Strokemax/InputMax|, |Strokemin/InputMin|)$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

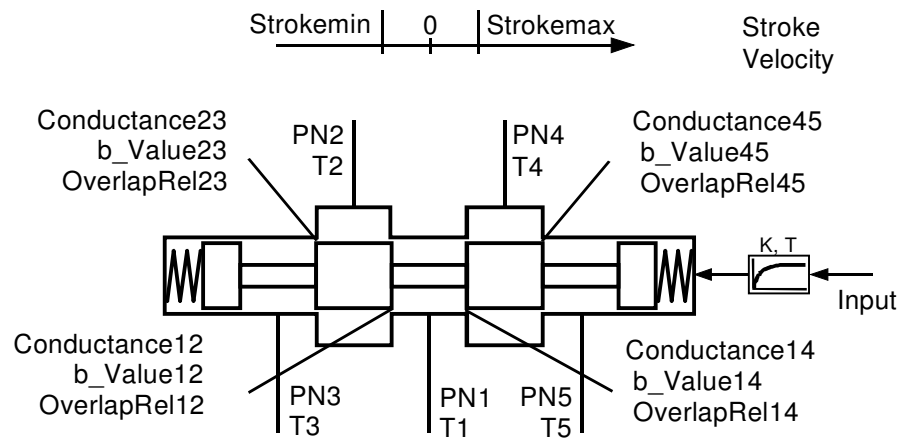
$OverlapRel < 0$: metering edge in normal position open
 $OverlapRel = 0$: metering edge in normal position just closed
 $OverlapRel > 0$: metering edge in normal position closed

PneuProportionalvalve53PT1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Velocity	Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3

Name	Type	Unit	Description
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative Overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative Overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative Overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel45	0	%	relative Overlap of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>

Name	Value	Unit	Description
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemin</i>
Conductance45	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 and 3
b_Value45	0.528	-	critical pressure ratio of the flow between the connectors 4 and 5
TimeConstant	10	ms	parameter to the control characteristic (<i>T</i>)

Notes

The component PNEUPROPORTIONALVALVE53PT1 is the model of a pneumatic 5/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal with a delay of the first order.

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₁-behavior is determined by proportional factor *K* and *TimeConstant* between the *Input* and the *Stroke* of the spool:

$$Velocity = (K \cdot Input - Stroke) / TimeConstant$$

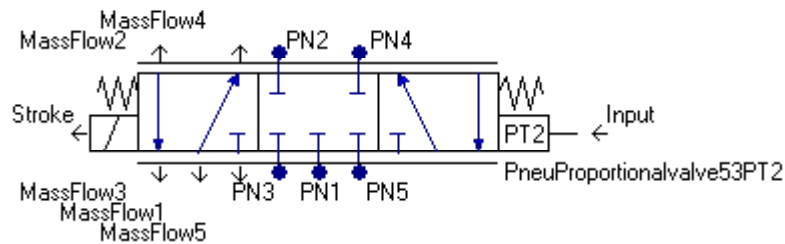
$$\text{with } K = \max(|Stroke_{max}/Input_{Max}|, |Stroke_{min}/Input_{Min}|).$$

The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

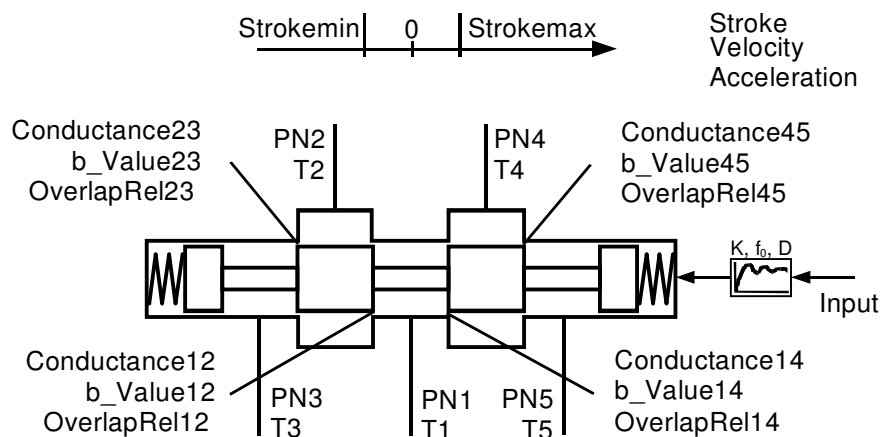
$OverlapRel < 0$: Metering edge in normal position open
 $OverlapRel = 0$: Metering edge in normal position just closed
 $OverlapRel > 0$: Metering edge in normal position closed

PneuProportionalvalve53PT2



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure
PN2	Pneu	bar	working pressure 2
PN3	Pneu	bar	ventilation 3
PN4	Pneu	bar	working pressure 4
PN5	Pneu	bar	ventilation 5
T1	Pneu	K	temperature in connector 1
T2	Pneu	K	temperature in connector 2
T3	Pneu	K	temperature in connector 3
T4	Pneu	K	temperature in connector 4
T5	Pneu	K	temperature in connector 5
Input	In	-	input signal to the spool stroke
Acceleration	Out	m/s ²	acceleration of the spool
Velocity	V-Out	m/s	velocity of the spool
Stroke	V-Out	mm	stroke of the spool
MassFlow1	Out	kg/s	mass flow in connector 1

Name	Type	Unit	Description
MassFlow2	Out	kg/s	mass flow in connector 2
MassFlow3	Out	kg/s	mass flow in connector 3
MassFlow4	Out	kg/s	mass flow in connector 4
MassFlow5	Out	kg/s	mass flow in connector 5

Parameters

Name	Value	Unit	Description
Strokemax	1	mm	maximum spool stroke in positive direction
Strokemin	-1	mm	minimum spool stroke in negative direction
Velocitymax	1E99	m/s	velocity limit to the spool motion in positive direction
Velocitymin	-1E99	m/s	velocity limit to the spool motion in negative direction
InputMax	1	-	input signal at <i>Stroke = Strokemax</i>
InputMin	-1	-	input signal at <i>Stroke = Strokemin</i>
OverlapRel12	0	%	relative overlap of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>
OverlapRel14	0	%	relative overlap of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
OverlapRel23	0	%	relative overlap of the metering edge between the connectors 2 and 3 at <i>Stroke = Strokemax</i>
OverlapRel45	0	%	relative overlap of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas
Conductance12	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 2 at <i>Stroke = Strokemax</i>

Name	Value	Unit	Description
Conductance14	1	NI/s/bar	conductance of the metering edge between the connectors 1 and 4 at <i>Stroke = Strokemax</i>
Conductance23	1	NI/s/bar	conductance of the metering edge between the connectors 2 und 3 at <i>Stroke = Strokemin</i>
Conductance45	1	NI/s/bar	conductance of the metering edge between the connectors 4 and 5 at <i>Stroke = Strokemax</i>
b_Value12	0.528	-	critical pressure ratio of the flow between the connectors 1 and 2
b_Value14	0.528	-	critical pressure ratio of the flow between the connectors 1 and 4
b_Value23	0.528	-	critical pressure ratio of the flow between the connectors 2 und 3
b_Value45	0.528	-	critical pressure ratio of the flow between the connectors 4 and 5
EigenFrequency	20	Hz	EigenFrequency of the undamped valve control (f_0)
Damping	0.7	-	damping of the valve control (D)

Notes

The component PNEUPROPORTIONALVALVE53PT2 is the model of a pneumatic 5/3-directional proportional valve. The flow characteristic that defines the aperture cross-section in dependence of the stroke, is defined by a look-up table. The spool stroke is proportional to the input signal, with a delay of the second order

The flow characteristics of the metering edges of the valve are defined by parameters to conductance's and critical pressure ratios.

The component does not represent a physical model of the valve but only its characteristic properties. Therefore the physical properties (e. g. mass of the spool, stiffness of the spring) are not defined. There is also no heat transfer to the environment.

Is the *Strokemin* > *Strokemax*, resp. *InputMin* > *InputMax*, the stroke limits or the *Input* are automatically transferred inside. Both processes are pointed out by message windows.

The control characteristic of the valve with PT₂-behavior is determined by *EigenFrequency* f_0 , *Damping* D and Proportional factor K between the *Input* and the *Stroke* of the spool:

$$\text{Acceleration} = \frac{K}{-2 \frac{(2\pi \text{EigenFrequency})^2}{\text{Damping}} (2\pi \text{EigenFrequency}) \text{Input Velocity} - (2\pi \text{EigenFrequency})^2 \text{Stroke}}$$

with $K = \max(|\text{Strokemax}/\text{InputMax}|, |\text{Strokemin}/\text{InputMin}|)$.

Velocity and *Stroke* are integrated out of the *Acceleration* of the spool. The *Velocity* so is possibly limited by the parameters *Velocitymax* und *Velocitymin*.

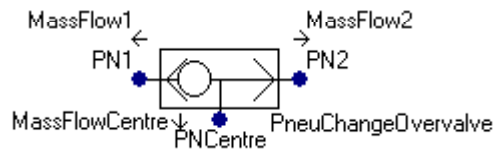
The parameter of the relative overlap *OverlapRel12* defines the relation between the overlap resp. the opened cross-section and the maximum spool stroke.

The following rule is effective:

OverlapRel < 0 Metering edge in normal position open
 OverlapRel = 0 Metering edge in normal position just closed
 OverlapRel > 0 Metering edge in normal position closed

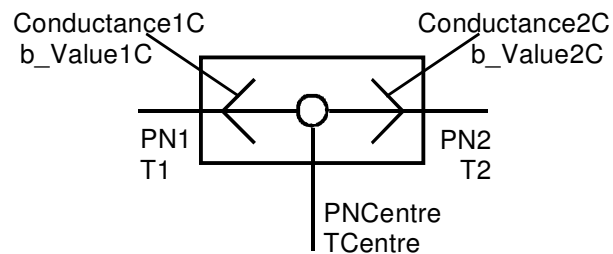
CheckValves

PneuChangeOvervalve



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure 1
PN2	Pneu	bar	supply pressure 2
PNCentre	Pneu	bar	working pressure
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
TCentre	Pneu	K	temperature of the gas in the working connector
MassFlow1	Out	kg/s	mass flow at connector 1
MassFlow2	Out	kg/s	mass flow at connector 2
MassFlowCentre	Out	kg/s	mass flow at the working connector

Parameters

Name	Value	Unit	Description
Conductance1C	1	NI/s/bar	conductance of the valve resistance between the connectors <i>PN1</i> and <i>PNCentre</i>
b_Value1C	0.528	-	critical pressure ratio of the valve resistance between the connectors <i>PN1</i> and <i>PNCentre</i>
Conductance2C	1	NI/s/bar	conductance of the valve resistance between the connectors <i>PN2</i> and <i>PNCentre</i>
b_Value2C	0.528	-	critical pressure ratio of the valve resistance between the connectors <i>PN2</i> and <i>PNCentre</i>
PolytropicExponent	1.4	-	polytropic exponent of the gas

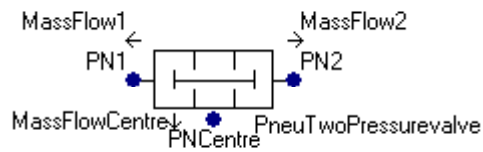
Notes

The component PNEUCHANGEOVERVALVE is the model of a valve, which's working connector *PNCentre* always is connected at the supply connectors, which reveals the higher pressure level (*PN1* or *PN2*). The direction of the mass flow results in the pressure difference between *PNCentre* and *PN1* resp. *PN2*.

The seats of the valves are calculated as resistances, which flow characteristics are set by the parameters *Conductance1C* and *b_Value1C* resp. *Conductance2C* and *b_Value2C*.

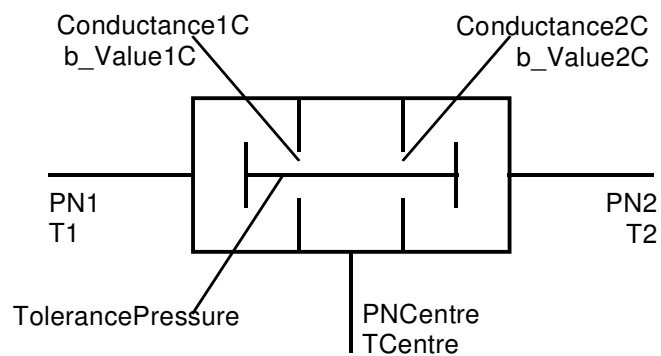
The component is no model of the physical construction of the valve; it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. masses or spring stiffness). There is also no heat transfer to the environment, because of the small valve dimensions.

PneuTwoPressurevalve



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure 1
PN2	Pneu	bar	supply pressure 2
PNCentre	Pneu	bar	working connector
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
TCentre	Pneu	K	temperature of the gas in the working connector
MassFlow1	Out	kg/s	mass flow at connector 1
MassFlow2	Out	kg/s	mass flow at connector 2
MassFlowCentre	Out	kg/s	mass flow at the working connector

Parameters

Name	Value	Unit	Description
TolerancePressure	1	bar	maximum pressure difference between <i>PN1</i> and <i>PN2</i> , at which a <i>MassFlowCentre</i> results
Conductance1C	1	NI/s/bar	conductance of the valve resistance from <i>PN1</i> to <i>PNCentre</i>
b_Value1C	0.528	-	critical pressure ratio of the valve resistance from <i>PN1</i> to <i>PNCentre</i>
Conductance2C	1	NI/s/bar	conductance of the valve resistance from <i>PN2</i> to <i>PNCentre</i>
b_Value2C	0.528	-	critical pressure ratio of the valve resistance from <i>PN2</i> to <i>PNCentre</i>
PolytropicExponent	1.4	-	Polytropic exponent of the gas

Notes

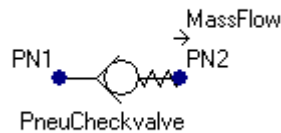
The component *PNEUTWOPRESSUREVALVE* is the model of a valve, which's working connector *PNCentre* only is connected to the supply connector *PN1* and *PN2*, if the pressure difference between supply connectors is not greater than the tolerance pressure.

The *MassFlowCentre* is the sum of the *MassFlow1* and *MassFlow2*. The direction of the mass flow is the result of the pressure difference between *PNCentre* and *PN1* resp. *PN2*.

The flow characteristics of the valve are set by the parameters *Conductance1C* and *b_Value1C* resp. *Conductance2C* and *b_Value2C*.

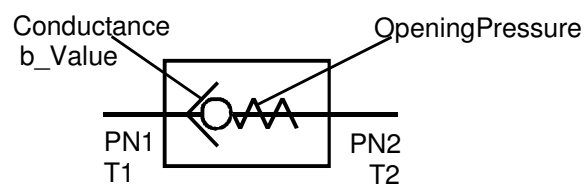
The component is no model of the physical construction of the valve; it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. damper mass or spring stiffness). There is also no heat transfer to the environment, because of the small valve dimensions.

PneuCheckValve



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure1
PN2	Pneu	bar	supply pressure2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow through the valve

Parameters

Name	Value	Unit	Description
Conductance	1	l/s/bar	conductance of the valve from <i>PN1</i> to <i>PN2</i>
b_Value	0.528	-	critical pressure ratio
PolytropicExponent	1.4	-	polytropic exponent of the gas
OpeningPressure	1	bar	Pressure difference between <i>PN1</i> and <i>PN2</i> , at which the valve opens

Notes

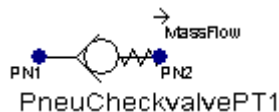
The component PNEUCHECKVALVE is the model of a pneumatic check valve, which stops the mass flow in the direction from *PN2* to *PN1* and releases it in contrary direction from *PN1* to *PN2*.

The opened valve conducts like a resistance, which's flow characteristic is set by the parameters *Conductance* and *b_Value*.

The *OpeningPressure* is the pressure, which corresponds to the pre-tension. The opening condition hence is: $PN1 > PN2 + \textit{OpeningPressure}$.

The component is no model of the physical construction of the valve; it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. damper mass or spring stiffness). There is also no heat transfer to the environment, because of the small valve dimensions.

PneuCheckValvePT1



Symbol

Sketch

Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	supply pressure1
PN2	Pneu	bar	supply pressure2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow through the valve

Parameters

Name	Value	Unit	Description
Conductance	1	NI/s/bar	conductance of the valve from <i>PN1</i> to <i>PN2</i>
b_Value	0.528	-	critical pressure ratio
PolytropicExponent	1.4	-	polytropic exponent of the gas
OpeningPressure	1	bar	Pressure difference between <i>PN1</i> and <i>PN2</i> , at which the valve opens
T	1	ms	time constant of the mechanical system that is not capable to oscillate

Notes

The component PNEUCHECKVALVE is the model of a pneumatic check valve, which stops the mass flow in the direction from *PN2* to *PN1* and releases it in contrary direction from *PN1* to *PN2*.

The opened valve conducts like a resistance, which's flow characteristic is set by the parameters *Conductance* and *b_Value*.

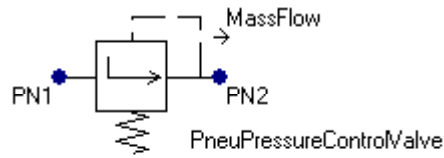
The *OpeningPressure* is the pressure, which corresponds to the pre-tension. The opening condition hence is: $PN1 > PN2 + OpeningPressure$.

The component is no model of the physical construction of the valve; it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. damper mass or spring stiffness). The dynamic effects which can occur in real valve such as forces due to inertia will be represented by means of the parameter T , which is the time constant of an idealized first order mechanical system that can not oscillate.

There is no heat transfer to the environment, because of the small valve dimensions.

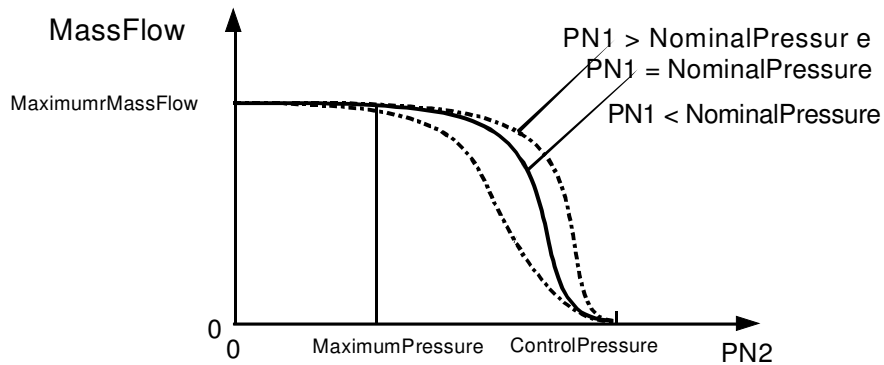
Pressure valves

PneuPressureControlValve



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	primary pressure
PN2	Pneu	bar	secondary pressure
T1	Pneu	K	temperature in connector1
T2	Pneu	K	temperature in connector2
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
ControlPressure	7	bar	secondary pressure, to be regulated by the control pressure
NominalPressure	10	bar	nominal pressure of the controller
MaximumPressure	3	bar	secondary pressure, up to which the mass flow is constant

Name	Value	Unit	Description
MaximumMassFlow	0.05	kg/s	maximum mass flow (= <i>MassFlow</i> at <i>PN2</i> = pressure of the environment)

Notes

The component PNEUPRESSURE CONTROLVALVE is the model of a control valve, which keeps the secondary pressure constant *PN2* independent of the *MassFlow* and the primary pressure *PN1* within definite ranges. This control valve as a rule is the first flown of a resistance pneumatic systems.

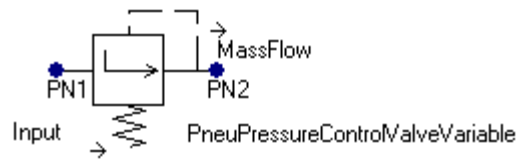
At *NominalPressure*, the regulator is able to keep the *ControlPressure* exactly to *MassFlow* = 0. With an increasing *MassFlow* the pressure anyway falls down continuously, until the maximum mass flow (*MaximumMassFlow*) is reached at a limit pressure (*MaximumPressure*). From this limit pressure the *MassFlow* does not rise anymore. The *MassFlow* in the zone between *MaximumPressure* and *ControlPressure* is appropriated by an empirically founded hyperbolic function. If there are deviations to the *NominalPressure* the control function will be corrected accordingly.

The component is no model of the physical construction of the valve, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e.g. damper mass or spring stiffness). There is also no heat transfer to the environment.

The *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

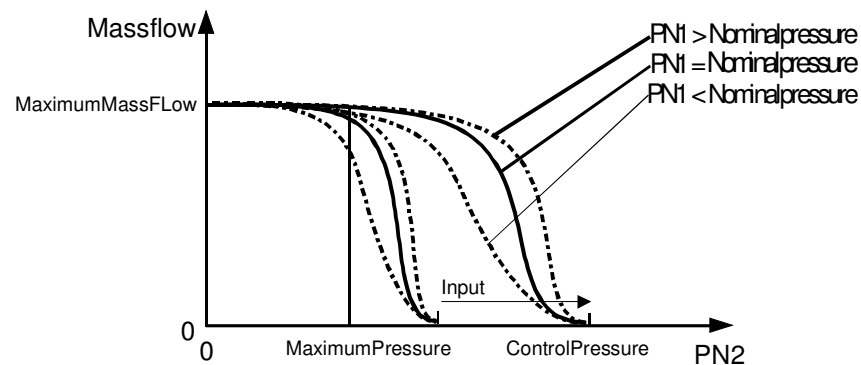
A model of the pneumatic control valve, is available as a component, which's flow characteristic is named by a look-up table to the mass flow (*MassFlow _Characteristic*) in dependence of *PN2* (PNEUPRESSURECONTROLVALVECHARACTERISTIC1).

PneuPressureControlValveVariable



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	primary pressure
PN2	Pneu	bar	secondary pressure
T1	Pneu	K	temperature in connector1
T2	Pneu	K	temperature in connector2
MassFlow	Out	kg/s	mass flow
Input	In		Inputs signal to adjust the ControlPressure

Parameters

Name	Value	Unit	Description
ControlPressure	7	bar	secondary pressure, to be regulated by the control pressure
NominalPressure	10	bar	nominal pressure of the controller
MaximumPressure	3	bar	secondary pressure, up to which the mass flow is constant

Name	Value	Unit	Description
MaximumMassFlow	0.05	kg/s	maximum mass flow (= <i>MassFlow</i> at <i>PN2</i> = pressure of the environment)

Notes

The component PNEUPRESSURECONTROLVALVEVARIABLE is the model of a control valve, which keeps the secondary pressure constant *PN2* independent of the *MassFlow* and the primary pressure *PN1* within definite ranges. The *ControlPressure* can be adjusted with the *Input*.

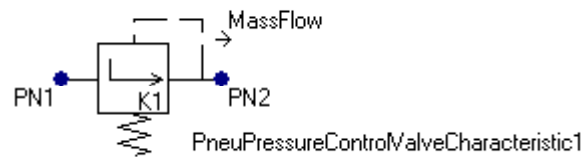
At *NominalPressure*, the regulator is able to keep the *ControlPressure* exactly to *MassFlow* = 0. With an increasing *MassFlow* the pressure anyway falls down continuously, until the maximum mass flow (*MaximumMassFlow*) is reached at a limit pressure (*MaximumPressure*). From this limit pressure the *MassFlow* does not rise anymore. The *MassFlow* in the zone between *MaximumPressure* and *ControlPressure* is appropriated by an empirically founded hyperbolic function. If there are deviations to the *NominalPressure* the control function will be corrected accordingly.

The component is no model of the physical construction of the valve, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e.g. damper mass or spring stiffness). There is also no heat transfer to the environment.

The *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

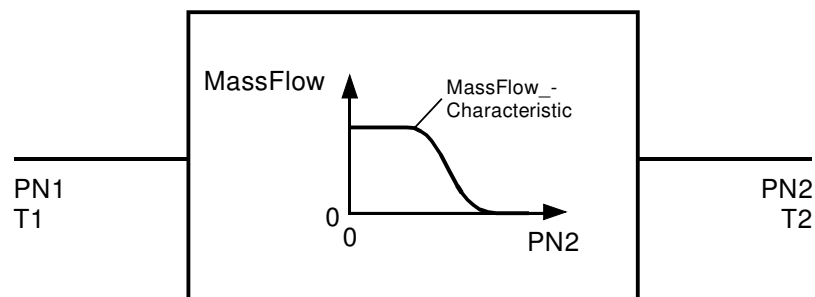
A model of the pneumatic control valve, is available as a component, which's flow characteristic is named by a look-up table to the mass flow (*MassFlow _Characteristic*) in dependence of *PN2* (PNEUPRESSURECONTROLVALVECHARACTERISTIC1).

PneuPressureControlValveCharacteristic1



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	primary pressure
PN2	Pneu	bar	secondary pressure
T1	Pneu	K	temperature in connector1
T2	Pneu	K	temperature in connector2
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
NominalPressure	10	bar	nominal pressure of the controller
MassFlow_Characteristic	-1	-	look-up table of the mass flow in dependence of PN2

Notes

The component PNEUPRESSURECONTROLVALVECHARACTERISTIC1 is the model of a control valve, which keeps the secondary pressure constant $PN2$ independent of the $MassFlow$ and the primary pressure $PN1$ within definite ranges. This control valve as a rule is the first flown of a resistance pneumatic systems.

The flow characteristic of the controller is described by a look-up table to the mass flow ($MassFlow_Characteristic$) in dependence of $PN2$. Is there a deviation in $PN1$ to the $NominalPressure$, the flow function is corrected linear.

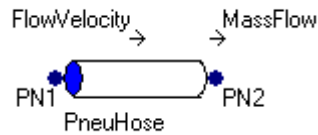
The component is no model of the physical construction of the valve, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e.g. damper mass or spring stiffness). There is also no heat transfer to the environment.

The *MassFlow* correlates to the connector *PN2*, i.e. a positive *MassFlow* means a flow direction from *PN1* to *PN2*.

A model of the pneumatic control valve, is available as a component, which's regulator characteristic is defined by parameters (PNEUPRESSURECONTROLVALVE).

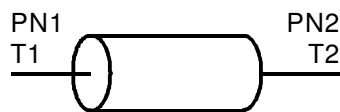
Resistances

PneuHose



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure at hose end 1
PN2	Pneu	bar	pressure at hose end 2
T1	Pneu	K	temperature of the gas at hose end 1
T2	Pneu	K	Temperaturee of the gas at hose end 2
MassFlow	Out	kg/s	mass flow
FlowVelocity	Out	M/s	flow velocity

Parameters

Name	Value	Unit	Description
Diameter	10	mm	diameter of the hose
Length	100	mm	length of the hose
Alpha	75	W/m ² /K	heat transfer number
PolytropicExponent	1.4	-	polytropic exponent of the gas
TDifference	0	K	Temperature Difference of the
AltitudeDifference	0.	m	Difference in height between the tube ends

Notes

The component PNEUHose is the model of a pneumatic hose. This hose is identified by geometric characteristic variables, of which's its conductance and the critical pressure ratios are calculated with an empirical founded formula. The pneumatic capacitance of the hose is considered by the nodes which are connected to the hose. The hose volume is added to the nodes. There either a heat transfer with the environment is considered.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

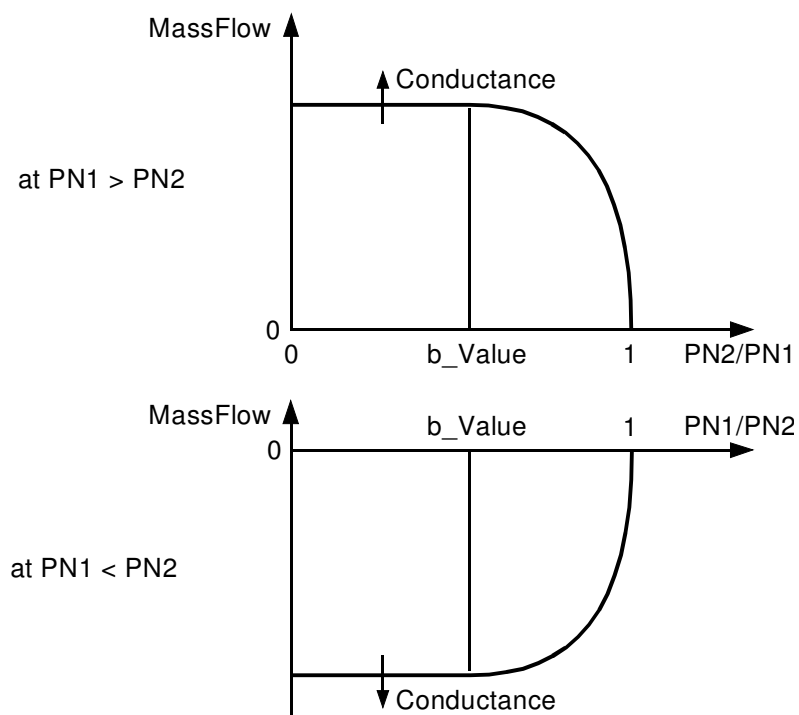
With the help of the parameter *AltitudeDifference* a difference in height between the hose connectors can be considered. The parameter *AltitudeDifference* has to be > 0 if *PN2* is in a higher position.

PneuResistance



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
Conductance	1	NI/s/bar	conductance of the resistance
b_Value	0.528	-	critical pressure ratios
Polytropic exponent	1.4	-	polytropic exponent of the gas

Notes

The component PNEURESISTANCE is the model of a constant pneumatic resistance.

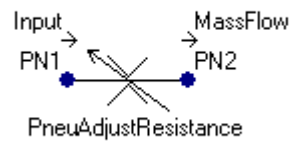
The flow characteristic is set by the parameters *Conductance* and *b_Value*.

The component is no model of the physical construction of a resistance, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. cross section area). There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

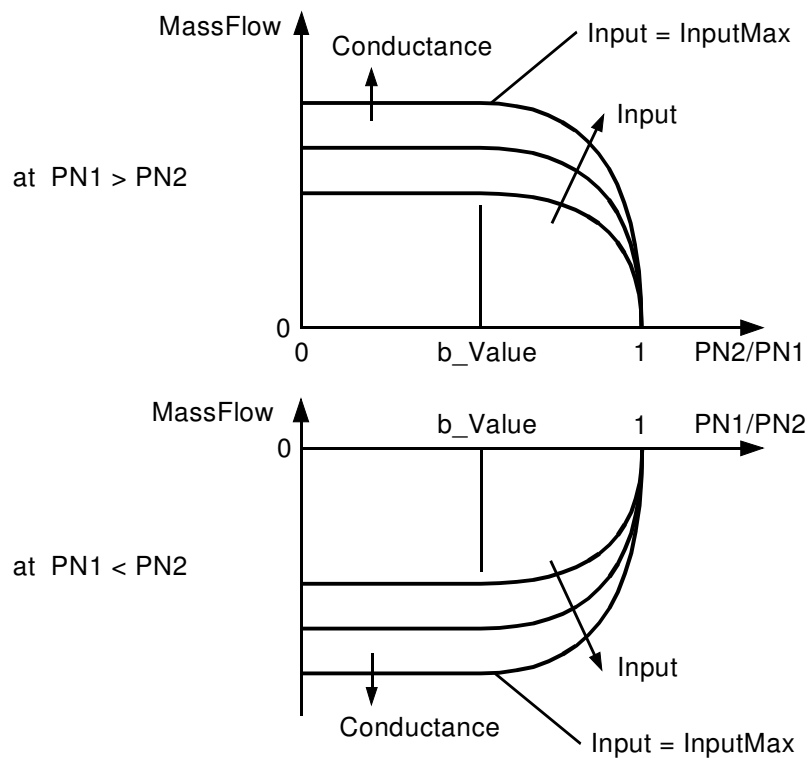
A model of the pneumatic resistance is available as a component, which's flow characteristic can be adjusted by an input signal (PNEUADJUSTRESISTANCE).

PneuAdjustResistance



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
Input	In	-	input signal
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
Conductance	1	NI/s/bar	conductance of the resistance at <i>Input</i> = <i>InputMax</i>
b_Value	0.528	-	critical pressure ratios
PolytropicExponent	1.4	-	polytropic exponent of the gas
InputMax	1	-	maximum input signal

Notes

The component PNEUADJUSTRESISTANCE is the model of a pneumatic resistance which can be adjusted proportionally to the inputsignal.

The flow characteristic is set by parameters *Conductance* and *b_Value*.

The component is no model of the physical construction of a resistance, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. cross section area). There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

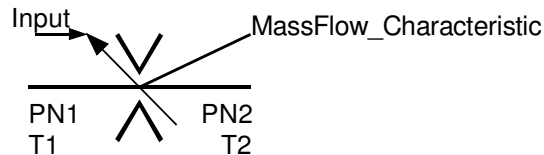
A model of a pneumatic resistance is available as a component with constant flow characteristic (PNEURESISTANCE).

PneuAdjustResistanceCharacteristic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
Input	In	-	input signal
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
MassFlow_Characteristic	-1	-	look-up table of the mass flow through the resistance in dependence of the supply pressure and the pressure ratio
InputMax	1	-	maximum input signal

Notes

The component PNEUADJUSTRESISTANCECHARACTERISTIC is the model of a pneumatic resistance which can be adjusted proportionally to the input signal.

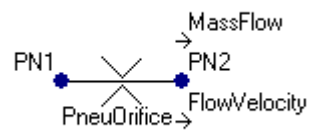
The flow characteristic is set by a two dimensional look-up table. In this look-up table the mass flow is exaggerated through the pre-pressure (Input 1 of the look-up table) and the pressure ratio (Input 2 of the look-up table). At $PN1 > PN2$ the pre-pressure is $PN1$ and the pressure ratio is $PN2/PN1$. At $PN2 > PN1$ the pre-pressure is $PN2$ and the pressure ratio is $PN1/PN2$.

The component is no model of the physical construction of a resistance, it rather reproduces its characteristic attributes. Consequently physical parameters are not used (e. g. cross section area). There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

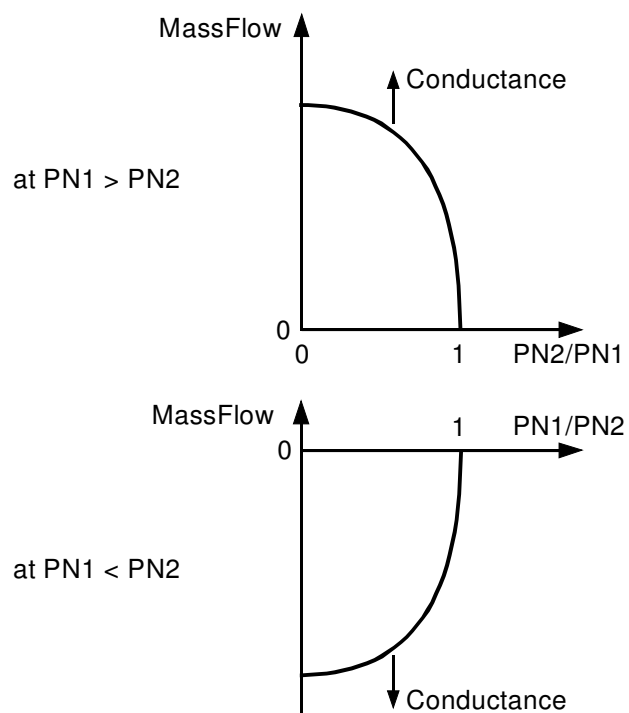
A model of a pneumatic resistance is available as a component, which's flow characteristic is set to parameters to the conductance and the critical pressure ratio (PNEUADJUSTRESISTANCE).

PneuOrifice



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
Diameter	10	mm	floated diameter of the orifice

Name	Value	Unit	Description
AlphaD	0.65	-	resistance coefficient
PpolytropicExponent	1.4	-	polytropic exponent of the gas

Notes

The component PNEUORIFICE ist is the model of a pneumatic resistance. The flow characteristic is set by the conductance.

The conductance is determined by the physical construction of the resistance and has to be calculated with this formula:

$$C = \frac{\alpha_D A \Psi_{\max} \cdot \sqrt{2 R_{L,0} T_0}}{p_0}$$

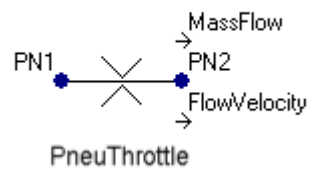
The *b_Value* is set to zero, the whole pressure range is calculated with under-critical flow function.

There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

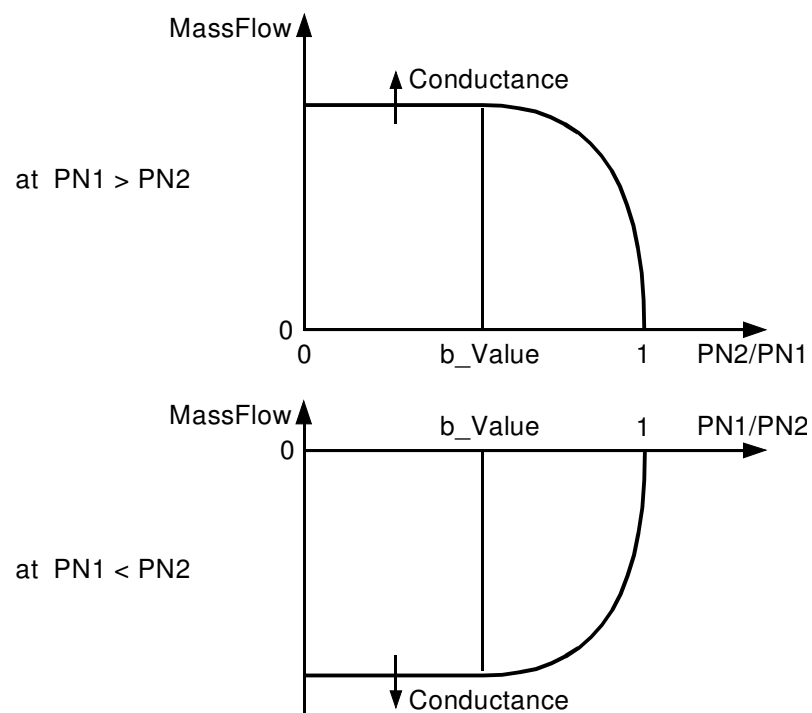
A model of a pneumatic resistance is available as a component, which's flow characteristic is to be adjusted by an input signal.

PneuThrottle



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
CrossSectionArea	10	mm ²	cross section area of the throttle

Name	Value	Unit	Description
Alpha_D	0.65	-	resistance coefficient
b_Value	0.45	-	critical pressure ratios
PolytropicExponent	1.4	-	polytropic exponent of the gas

Notes

The component PNEUTHROTTLE is the model of a pneumatic constant resistance.

The flow characteristic is determined by the *Conductance* and the parameter *b_Value*. The conductance is determined by the physical construction of the resistance and has to be calculated with this formula:

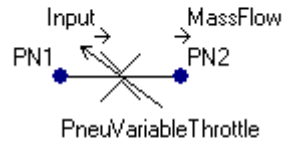
$$C = \frac{\alpha_D A \Psi_{\max} \cdot \sqrt{2 R_{L,0} T_0}}{p_0}$$

There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

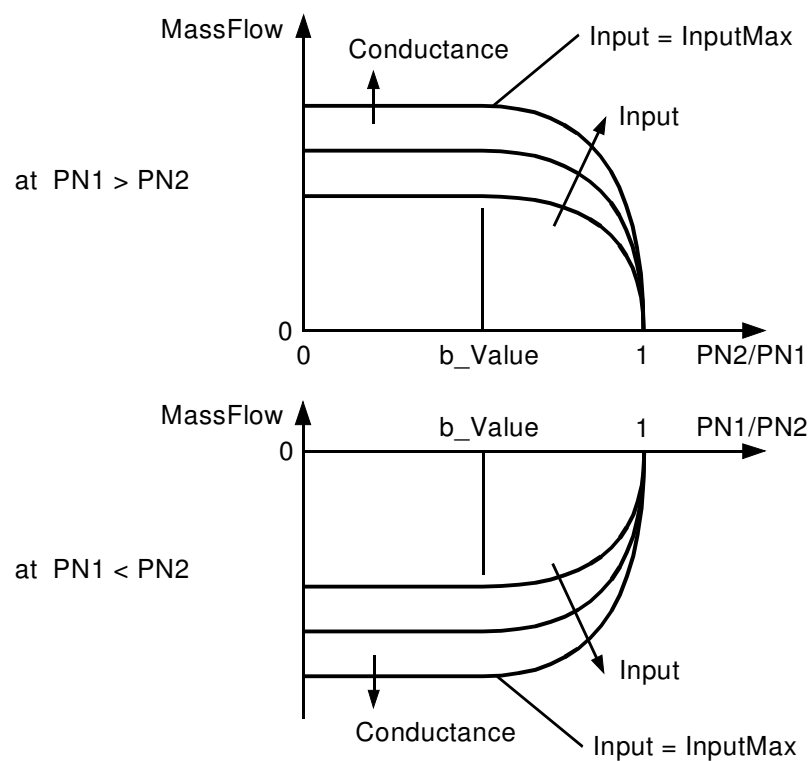
A model of a pneumatic throttle is available as a component, which's flow characteristic is to be adjusted by an input signal (PNEUADJUSTTHROTTLE).

PneuVariableThrottle



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
Input	In	-	input signal
MassFlow	Out	kg/s	mass flow

Parameters

Name	Value	Unit	Description
CrossSectionArea	10	mm ²	cross section area of the throttle
Alpha_D	0.65	-	resistance coefficient
b_Value	0.528	-	critical pressure ratios
PpolytropicExponent	1.4	-	Polytropic exponent of the gas
InputMax	1	-	maximum input signal

Notes

The component PNEUVARIABLETHROTTLE is the model of a pneumatic resistance, which can be adjusted proportionally to the input signal.

The flow characteristic is set by the *Conductance* and the parameter *b_Value*. The conductance is determined by the physical construction of the resistance and has to be calculated with this formula:

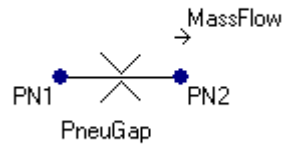
$$C = \frac{\alpha_D A \Psi_{\max} \cdot \sqrt{2 R_{L,0} T_0}}{p_0}$$

There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

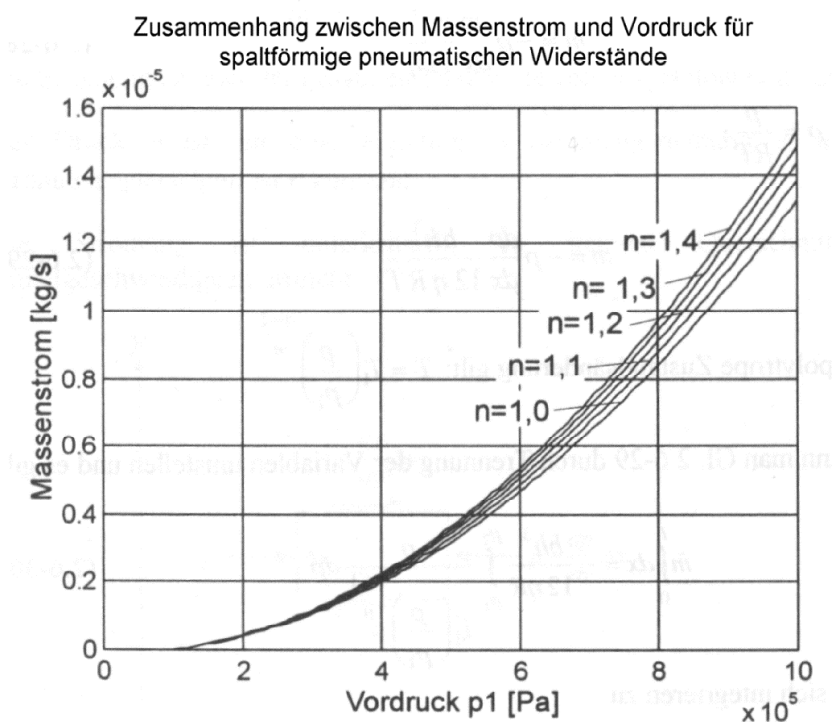
A model of a pneumatic throttle is available as a component, which's flow characteristic is constant (PNEUTHROTTLE).

PneuGap



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
PN2	Pneu	bar	pressure in connector 2
T1	Pneu	K	temperature of the gas in connector 1
T2	Pneu	K	temperature of the gas in connector 2
MassFlow	Out	kg/s	mass flow

Parameters

Notes

The component PNEUGAP is the model of a constant pneumatic resistance.

The flow characteristic has to be calculated with this formula:

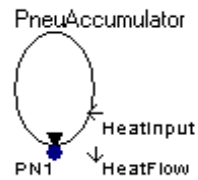
$$\dot{m} = \left(p_1^{\frac{n+1}{n}} - p_2^{\frac{n+1}{n}} \right) \frac{bh^3 p_1^{\frac{n-1}{n}} n}{12\eta RT_1 l(n+1)}$$

There is no heat transfer to the environment, because of the small geometric dimensions of a resistance.

The *MassFlow* correlates to the connector *PN2*, i. e. a positive *MassFlow* means a flow characteristic from *PN1* to *PN2*.

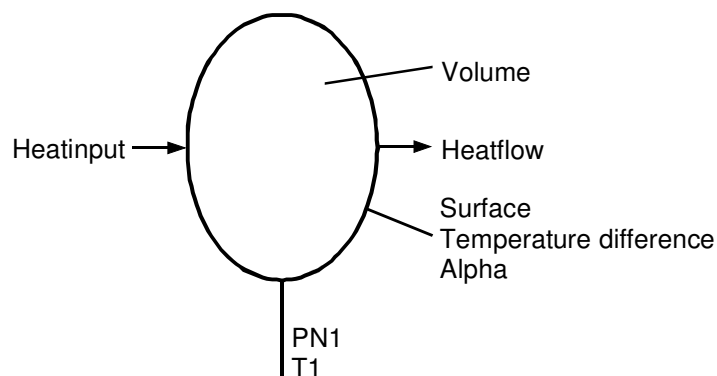
Miscellaneous

PneuAccumulator



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in the accumulator
T1	Pneu	K	temperature in the accumulator
HeatFlow	Out	W	heat flow through the surface of the accumulator
Heatinput	In	W	additional external heat flow

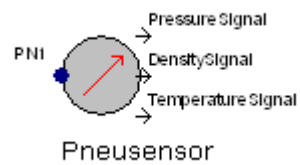
Parameters

Name	Value	Unit	Description
Volume	100	l	volume of the accumulator
SurfaceArea	1	m ²	surface of the accumulator
TDifference	0	k	local temperature difference to the global system temperature
Alpha	75	W/m ² /K	heat flow number of the surface of the accumulator

Notes

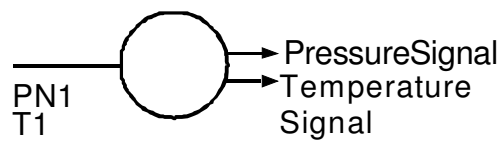
The component PNEUACCUMULATOR is the model of a pneumatic accumulator with constant *Volume*. The stored air is able to exchange heat with the environment through the surface of the accumulator, that influences the pressure in the accumulator.

PneuSensor



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector1
T1	Pneu	K	temperature in connector1
PressureSignal	Out	bar	signal connector for pressure
TemperatureSignal	Out	K	signal connector for temperature
DensitySignal	Out	kg/m ³	signal connenctor for density

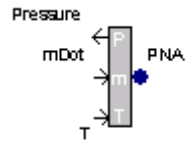
Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

The component PNEUSensor measures the pneumatic characteristics. If it is connected to a pneumatic node, pressure and temperature as well as density can be picked up at the signal connector (*PressureSignal*, *TemperatureSignal* and *DensitySignal*).

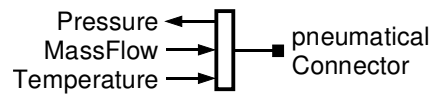
Pneu2Signal



Pneu2signal

Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PN1	Pneu	bar	pressure in connector 1
T1	Pneu	K	temperature in connector 1
Pressure	Out	bar	signal connector for the pressure measurement
mDot	In		signal input for mass flow
T	In	K	signal connector for temperature

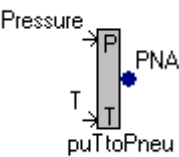
Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

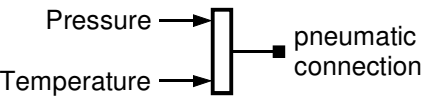
The component Pneu2Signal serves to set pneumatic ratios. If it is connected to a pneumatic node, the mass flow and the temperature are pre-set to this pneumatic node.

puTtoPneu



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
PNA	Pneu	bar	Pressure at connection PNA
Pressure	In	bar	Pressure input
T	In	K	Temperature input

Parameter

Name	Value	Unit	Description
-	-	-	-

Notes

The component puTtoPneu serves to set pneumatic ratios. If it is connected to a pneumatic node, the pressure and the temperature are pre-set to this pneumatic node.