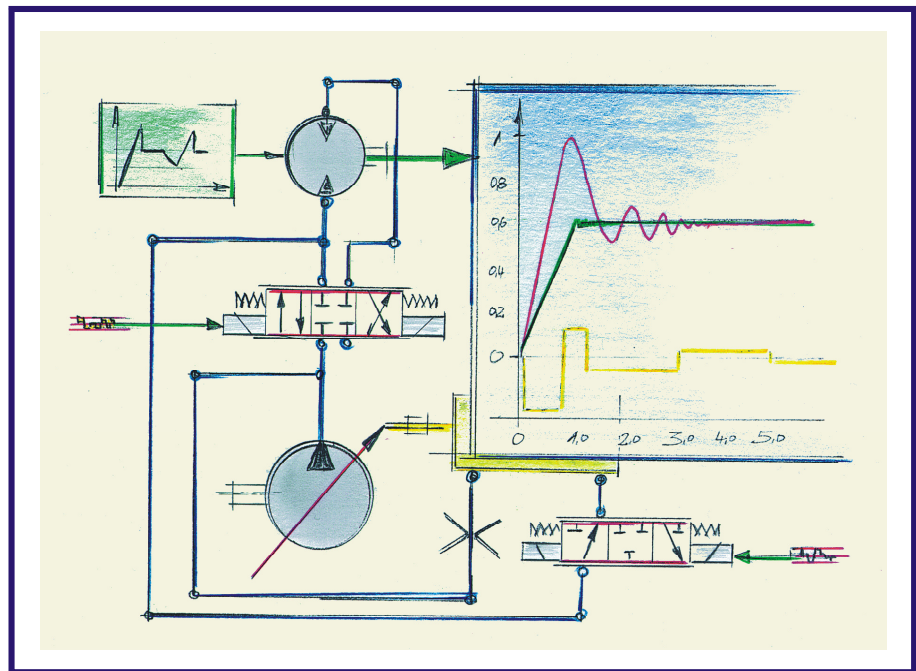


Component Manual

Mechanics



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>

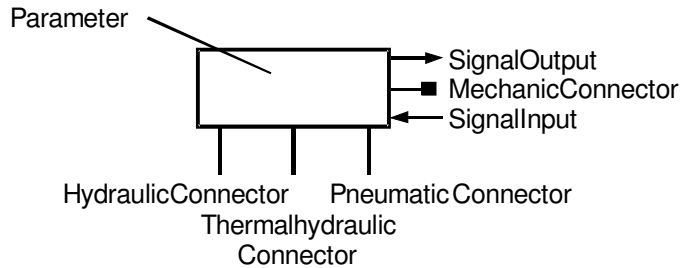
Parameters

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>														

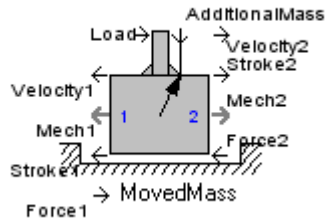
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Mechanics

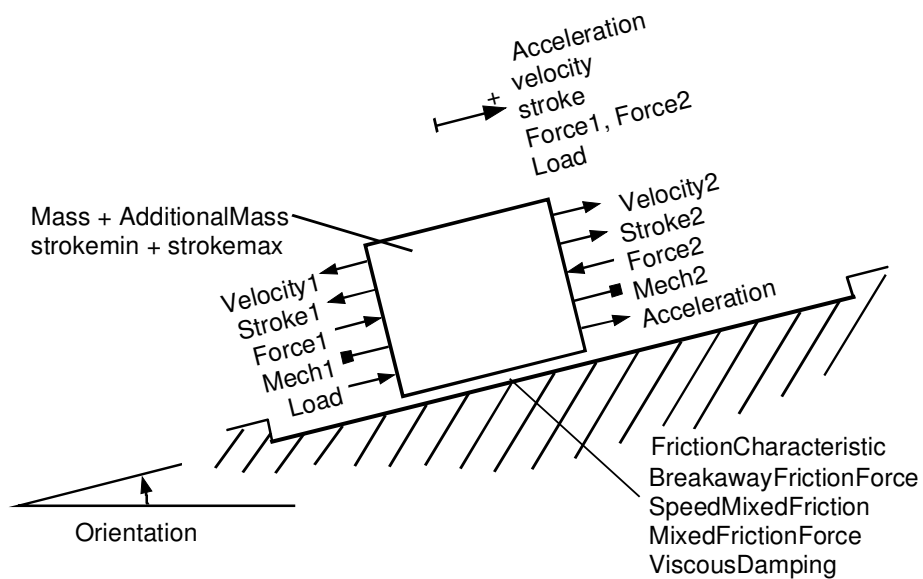
Masses

MovedMass



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Force1	In	N	force 1 applying at the mass
Force2	In	N	force 2 applying at the mass
Load	In	N	extra load at the mass
AdditionalMass	In	kg	variable part of the mass

Name	Type	Unit	Description
Mech1	Mech	-	mechanical connector 1
Mech1F	In	N	force applying at the
Mech1x	Out	mm	mass at side 1
Mech1v	Out	m/s	stroke of the mass
			velocity of the mass
Mech2	Mech	-	mechanical connector 2
Mech2F	In	N	force applying at the
Mech2x	Out	mm	mass at side 2
Mech2v	Out	m/s	stroke of the mass
			velocity of the mass
stroke	V	mm	stroke of the mass (internal auxiliary variable)
velocity	V	m/s	velocity of the mass (internal auxiliary variable)
Stroke1	Out	mm	stroke of the mass
Stroke2	Out	mm	stroke of the mass
Velocity1	Out	m/s	velocity of the mass
Velocity2	Out	m/s	velocity of the mass

Parameters

Name	Value	Unit	Description
Mass	10	kg	constant part of the mass
BreakawayFrictionForce	100	N	parameter for Stribeck-curve
MixedFrictionForce	10	N	parameter for Stribeck-curve
SpeedMixedFriction	0.1	m/s	parameter for Stribeck-curve
ViscousDamping	10	Ns/m	parameter for Stribeck-curve
Orientation	0	deg	angle between the movement plane and the horizontal plane
strokemax	1E69	mm	maximum mass stroke
strokemin	-1E69	mm	minimum mass stroke

Notes

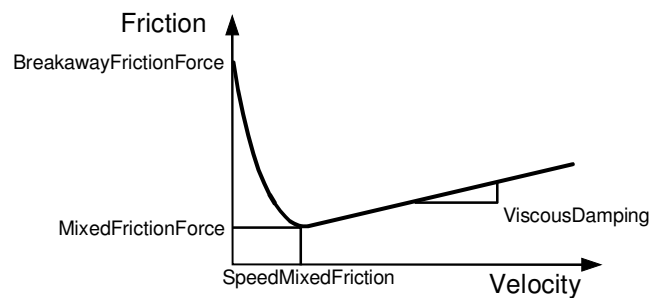
The component **MOVEDMASS** is the model of a mass which is moved on a level. The component can be used for simulation of a multi-body oscillator in connection with **SPRINGDAMPER** components.

An identical value is output to the connections *Stroke1* and *Stroke2* as well as to the connections *Velocity1* and *Velocity2* in each case. The connections are available in order to simplify the model structure.

For further simplification of the model structure, the component has the mechanical connectors *Mech1* and *Mech2*, with which the variables *Force1* and/or *Force2* as well as *stroke* and *velocity* can be transmitted summarized.

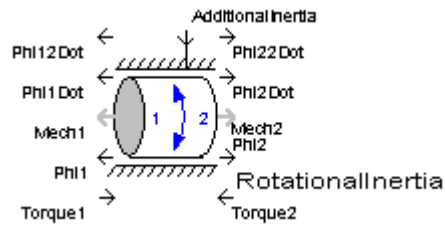
The total mass which is moved is the sum of *Mass* and *AdditionalMass*. With the *Orientation*, the movement plane can be sloped in any angle to the horizontal. The resulting force due to gravity is considered automatically.

The friction force is computed in accordance to the Stribeck curve. The parameters *BreakawayFrictionForce*, *MixedFrictionForce*, *SpeedMixedFriction*, and the *ViscousDamping* represents the characteristic values shown in the figure. The friction is not influenced by the inclination of the movement plane.



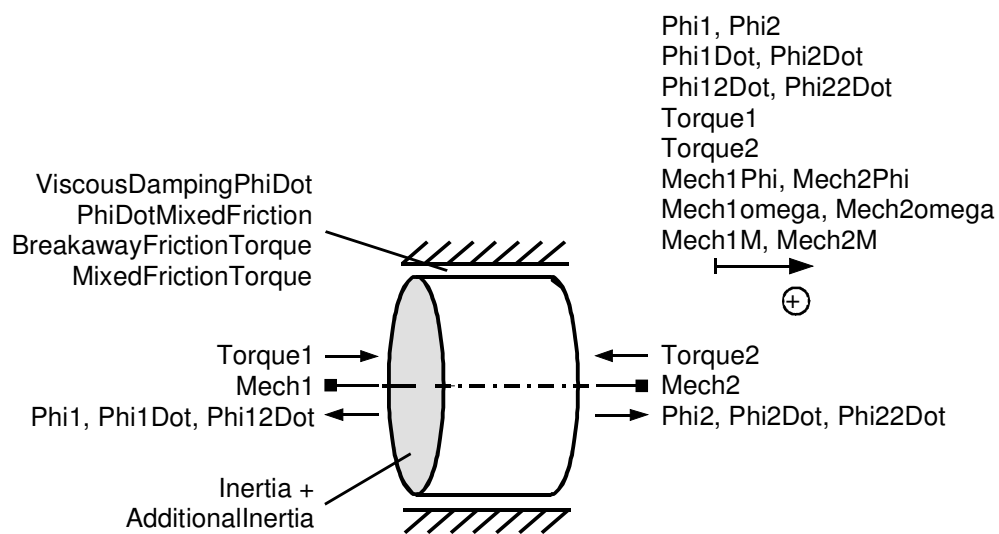
The friction is also definable with a look-up table ($F_{\text{friction}}(v)$). If a table is selected it will be used, if not, the normal parameters for the friction description are used. The look-up table is defined in one quarter only for positive velocity include 0. The component calculates with the absolute value.

RotationalInertia



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque 1 applying at the inertia
Torque2	In	Nm	torque 2 applying at the inertia
AdditionalInertia	In	kgm ²	variable part of the inertia
Mech1	Mech	-	mechanical connector 1
Mech1M	In	Nm	torque 1 applying at the inertia
Mech1phi	Out	Rad	angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connector 2
Mech2M	In	Nm	torque 2 applying at the inertia
Mech2phi	Out	rad	angle
Mech2omega	Out	rad/s	angular velocity
Phi	V	rad	angle (internal auxiliary variable)
PhiDot	V	rad/s	angular velocity (internal auxiliary variable)
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration

Parameters

Name	Value	Unit	Description
Inertia	0.05	kgm ²	constant part of the rotational inertia
ViscousDampingPhiDot	0.1	Nms/deg	parameter for Stribeck-curve
BreakawayFrictionTorque	1	Nm	parameter for Stribeck-curve
MixedFrictionTorque	1	Nm	parameter for Stribeck-curve
PhiDotMixedFriction	1	deg/s	parameter for Stribeck-curve

Notes

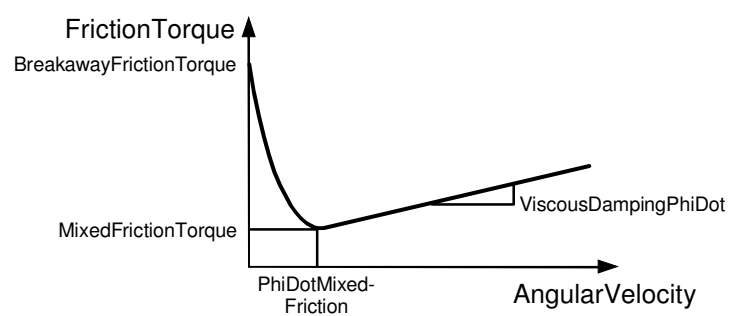
The component RotationalInertia is the model of a rotating body. The component can be used for simulation of a multi-body oscillator in connection with TorsionSpring components.

An identical value is output to the connections Phi1 and Phi2 as well as to the connections PhiDot1 and PhiDot2 in each case. The connections are available in order to simplify the model structure.

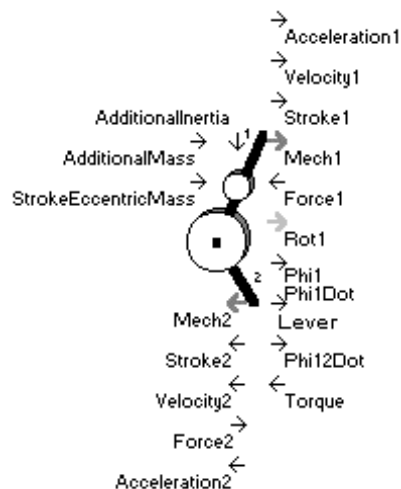
For further simplification of the model structure, the component has the mechanical connectors Mech1 and Mech2, with which the variables Torque1 and/or Torque2 as well as Phi and PhiDot can be transmitted summarized.

The total rotational inertia is the sum of Inertia and AdditionalInertia.

The friction force is computed in accordance to the Stribeck curve. The parameters BreakawayFrictionTorque, MixedFrictionTorque, PhiDotMixedFriction, and the ViscousDampingPhiDot represents the characteristic values shown in the figure.

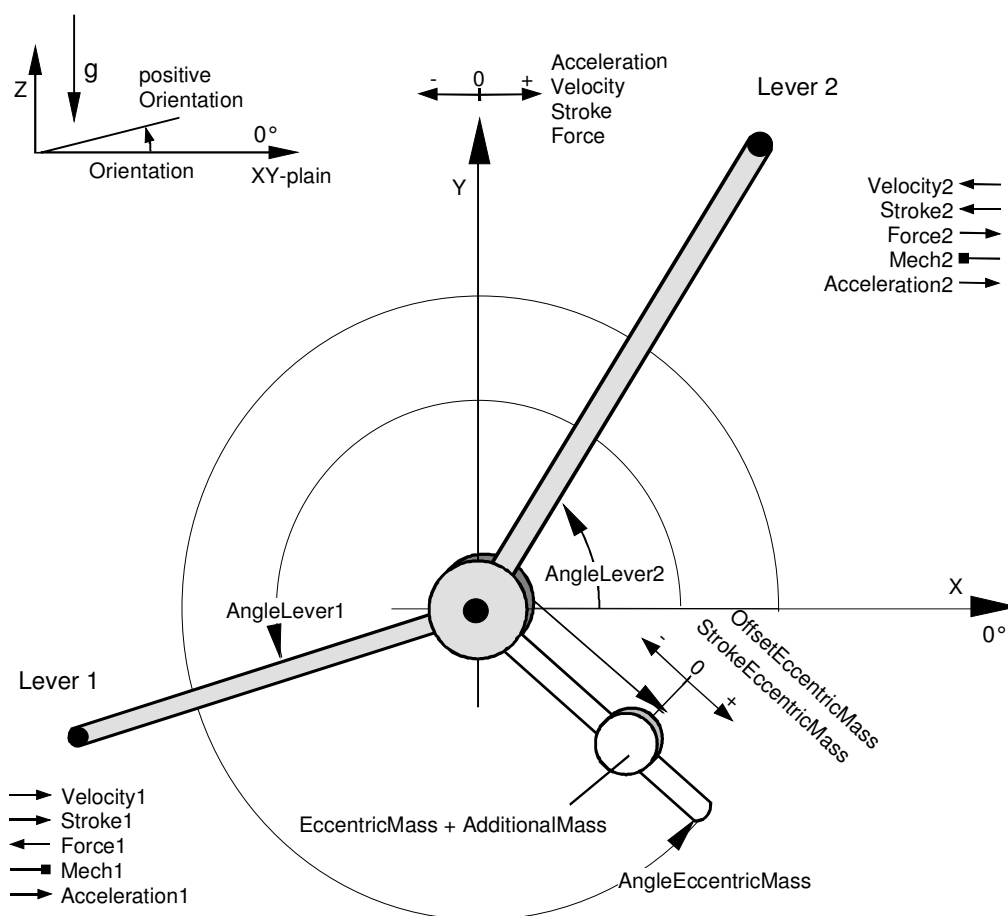


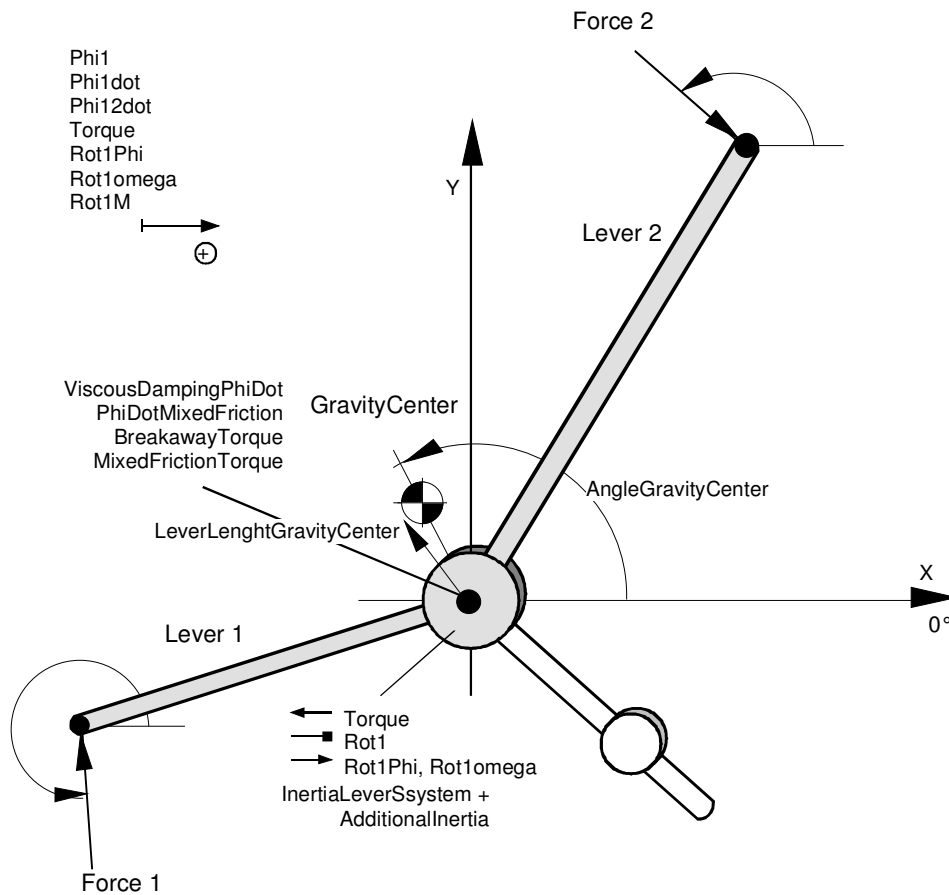
Lever



Symbol

Sketch





Connectors and Variables

Name	Type	Unit	Description
Phi	V	rad	angle (internal auxiliary variable)
PhiDot	V	rad/s	angular velocity (internal auxiliary variable)
Mech1	Mech	-	linear connector to lever 1
Mech1F	In	N	force applying to the lever 1
Mech1x	Out	mm	shift of the lever 1 towards the direction of force 1
Mech1v	Out	m/s	velocity of the lever 1 towards the direction of force 1

Name	Type	Unit	Description
Mech2	Mech	-	linear connector to lever 2
Mech2F	In	N	force applying to the lever 2
Mech2x	Out	Mm	shift of the lever 2 towards the direction of force 2
Mech2v	Out	m/s	velocity of the lever 2 towards the direction of force 2
Rot1	Mech	-	rotational connector to the lever system
Rot1M	In	Nm	torque
Rot1phi	Out	Rad	angle
Rot1omega	Out	rad/s	angular velocity
AdditionalInertia	In	kgm ²	variable part of the inertia
AdditionalMass	In	kg	variable part of the eccentric mass
StrokeEccentricMass	In	mm	variable part of the position of the eccentric mass
Torque	In	Nm	torque applied to the lever system
Force1	In	N	force 1 applied to the lever 1
Force2	In	N	force 2 applied to the lever 2
Stroke1	Out	mm	stroke of lever 1 towards the direction of force 1
Stroke2	Out	mm	stroke of lever 2 towards the direction of force 2
Velocity1	Out	m/s	velocity of lever 1 towards the direction of force 1
Velocity2	Out	m/s	velocity of lever 2 towards the direction of force 2
Acceleration1	Out	m/s ²	acceleration of lever 1 towards the direction of force 1
Acceleration2	Out	m/s ²	acceleration of lever 2 towards the direction of force 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity

Name	Type	Unit	Description
Phi12Dot	Out	rad/s ²	angular acceleration

Parameters

Name	Value	Unit	Description
InertiaLeverSystem	0.05	kgm ²	constant part of the rotational inertia
EccentricMass	10.	kg	constant part of the additional mass on lever 1
OffsetEccentricMass	0.	mm	start position of the additional mass on lever 1
LeverLength1	2000.	mm	length of lever 1
LeverLength2	100.	mm	length of lever 2
AngleLever1	0.	deg	angular offset of lever 1 respecting the horizontal plane
AngleLever2	0.	deg	angular offset of lever 2 respecting the horizontal plane
ViscousDampingPhiDot	0.1	Nms/deg	parameter for Stribeck-curve
BreakawayFrictionTorque	1	Nm	parameter for Stribeck-curve
MixedFrictionTorque	1	Nm	parameter for Stribeck-curve
PhiDotMixedFriction	1	deg/s	parameter for Stribeck-curve
Orientation	0.	deg	angle between the movement plane and the horizontal plane

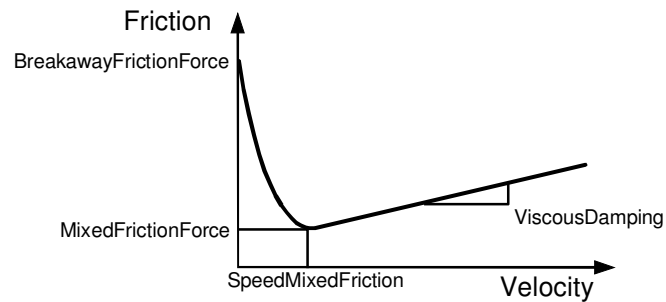
Notes

The component **LEVER** is a model of a lever system with inertia and optional eccentric mass. It can be combined with **TorsionSpring** components or **SpringDamper** components to simulate multi-body-systems. All effects but the coriolis accelerations caused by movements of the eccentric mass on a moved lever system are taken into consideration.

At the connectors *Stroke1*, *Velocity1*, and *Acceleration1* the state variables of the lever movement are available. Using the connector *Force1* an external force can be put on Lever 1. For Lever 2 there are identical connectors. At the connectors *Rot1Phi* and *Rot1Omega* the state variables of the rotational movement are available. Using the connector *MExternal* an external torque can be put on the lever system.

To simplify the modeling process there are the mechanical connectors *Mech1* and *Mech2* and *Rot1* summarizing *Force1*, *Force2* e. g. *Torque* and the according variables *Stroke* and *Velocity* e. g. *Rot1Phi* and *Rot1Omega*.

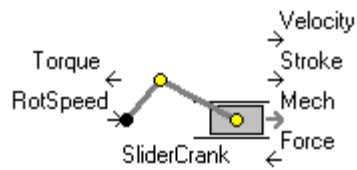
The friction force is computed in accordance to the Stribeck curve. The parameters *BreakawayFrictionForce*, *MixedFrictionForce*, *SpeedMixedFriction*, and the *ViscousDamping* represent the characteristic values shown in the figure.



The total inertia is the sum of *InertiaLeverSystem*, *Inertia*, and the inertia caused by the *EccentricMass* and its actual distance to the center.

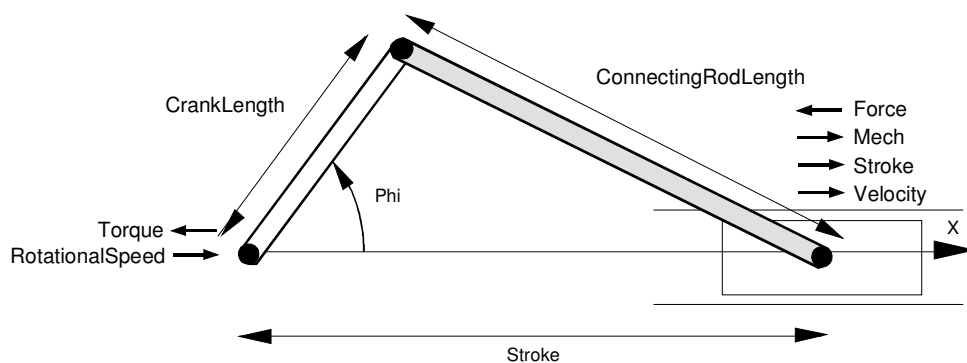
With the parameter *orientation* the whole lever system can be moved from a horizontal to a vertical position to add gravity effects.

SliderCrank



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Phi	V	deg	angle of the crank (internal auxiliary variable)
RotationalSpeed	In	deg/s	rotational speed of the crank
Stroke	Out	mm	stroke of the slide ring
Velocity	Out	m/s	velocity of the slide ring
Mech	Mech	-	translatory connector to slider crank
MechF	In	N	force applying to the slider crank
Mechx	Out	mm	shift of the slider crank towards the direction of force
Mechv	Out	m/s	velocity of the lever 1 towards the direction of force

Parameters

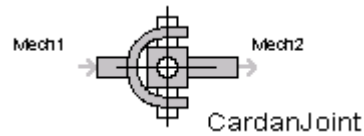
Name	Value	Unit	Description
CrankLength	50.	mm	length of the crank
ConnectingRodLength	100.	mm	length of the connecting rod

Notes

The component SLIDERCRAK is a model of a crank drive with no inertias, forces or accelerations taken into consideration. In combination with a cylinder e. g. it can be used to simulate reciprocating compressors. If the *ConnectingRodLength* is set to 0 the stroke represents a raw sine movement.

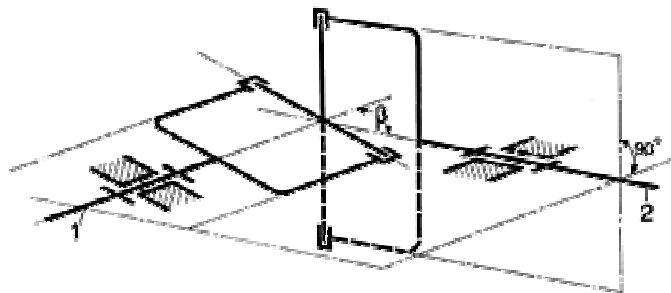
The backlash *Force* on the translatory connection represents the *Torque* on the rotational side.

CardanJoint



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque
Mech1phi	Out	rad	rotational angle 1
Mech1omega	Out	rad/s	angular acceleration 1
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque
Mech2phi	Out	rad	rotational angle 2
Mech2omega	Out	rad/s	angular acceleration 2

Parameters

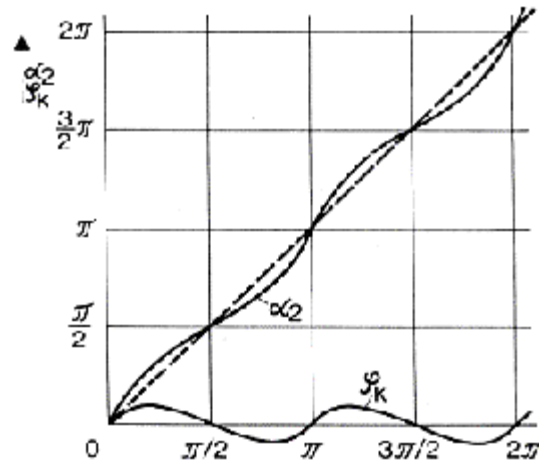
Name	Value	Unit	Description
ReferenceAngle	0.	deg	Angle difference of one fork plane to horizontal plane
ForkAngle	0.	deg	Angle β between drive shaft and output shaft

Notes

The component CARDANJOINT describes a special gear with an asymmetric transmission ratio. The transfer function can be described by the following equation.

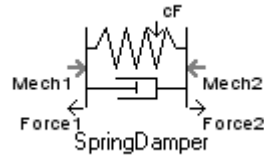
$$\alpha_2 = \arctan \left(\frac{1}{\cos \beta} \cdot \tan \alpha_1 \right)$$

α_2 is the actual rotational angel of the output shaft and α_1 is the actual rotational angel of the drive shaft. The motion behavior of the two shafts ends in dependency of the fork angel β is shown in the graphic.



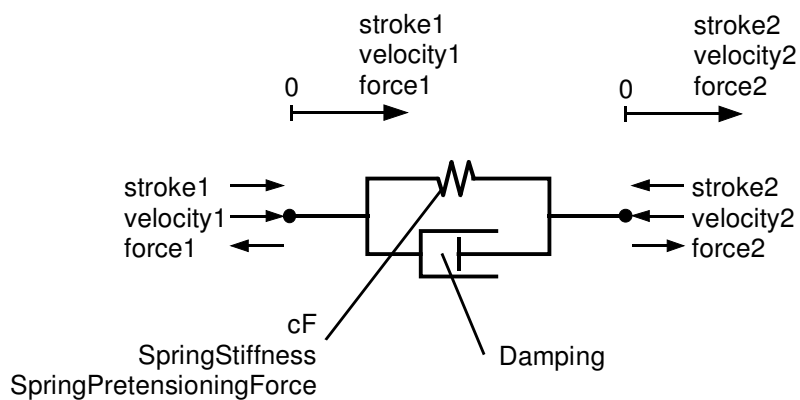
Spring-Damper-Components

SpringDamper



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Stroke1	In	mm	stroke of the connector 1
Stroke2	In	mm	stroke of the connector 2
Velocity1	In	m/s	velocity of connector 1
Velocity2	In	m/s	velocity of connector 2
Force1	Out	N	force applying at connector 1
Force2	Out	N	force applying at connector 2
cF	In	N/mm	variable spring stiffness
Mech1	Mech	-	mechanical Connector 1
Mech1F	In	N	Force at side 1
Mech1x	Out	Mm	Stroke
Mech1v	Out	m/s	Velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical Connector 2
Mech2F	In	N	Force at side 2
Mech2x	Out	Mm	Stroke
Mech2v	Out	m/s	Velocity

Parameters

Name	Value	Unit	Description
SpringStiffness	1	kN/mm	stiffness of the spring
Damping	1	kNs/m	velocity depending damping
SpringPretensioningForce	0	N	Pretensioning force of the spring
InitialStrokecompensation	1	-	starting value consideration

Notes

The component `SPRINGDAMPER` is a model of a spring damper system of which the spring and the damper have linear characteristics. The *SpringStiffness* can be varied by means of the connector `cF`.

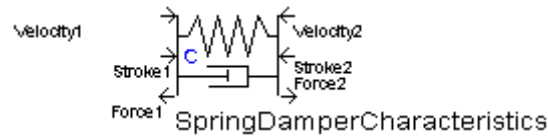
The overall spring stiffness is the sum of the *SpringStiffness* +`cF`. There is no limitation used, that means that the overall spring stiffness could be negative.

The component only works with stroke differences, not with absolute strokes. At the initial state, the spring has a Pretensioning independent of the initial values of *Stroke1* and *Stroke2* of *SpringPretensioningForce*.

This model of a spring damper element is also available as a component, at which the spring and the damper is parameterized with look-up tables so that not linear characteristics can be computed, too (`SPRINGDAMPERCHARACTERISTICS`).

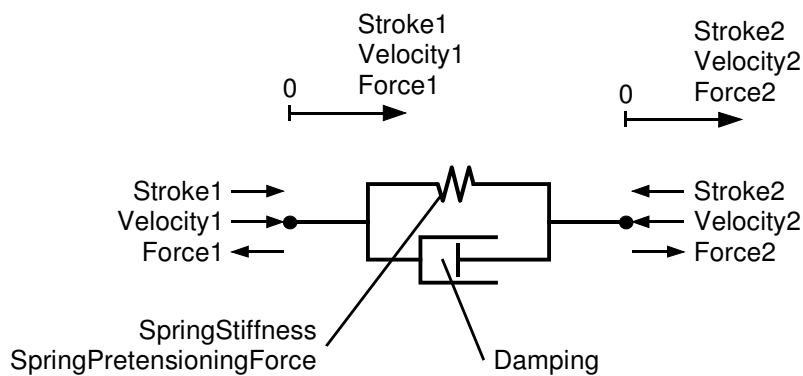
In addition, this model of a spring damper element summarizes the connections for the *stroke*, the *velocity* and the *force* in mechanical connector.

SpringDamperCharacteristics



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Stroke1	In	mm	stroke of the connector 1
Stroke2	In	mm	stroke of the connector 2
Velocity1	In	m/s	velocity of connector 1
Velocity2	In	m/s	velocity of connector 2
Mech1	Mech	-	mechanical Connector 1
Mech1F	In	N	Force at side 1
Mech1x	Out	Mm	Stroke
Mech1v	Out	m/s	Velocity
Mech2	Mech	-	mechanical Connector 2
Mech2F	In	N	Force at side 2
Mech2x	Out	Mm	Stroke
Mech2v	Out	m/s	Velocity

Parameters

Name	Value	Unit	Description
StrokeOffset	0	mm	Initial pre setting stroke
SignSpring	1		Algebraic sign for the <i>SpringforceCharacteristics</i>

Name	Value	Unit	Description
SignDamper	1	-	Algebraic sign for the <i>DampingforceCharacteristics</i>
InitialStrokecompensation	1	-	Starting value consideration
SpringforceCharacteristics	-		Stroke dependent spring force characteristics
DampingforceCharacteristics	-		Velocity dependent damping force characteristics

Notes

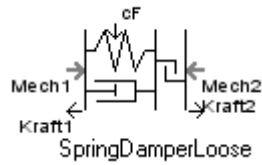
The component `SPRINGDAMPERCHARACTERISTICS` is a model of a spring damper system with look-up tables for the spring and the damper characteristics. With this it is possible to design nonlinear characteristics like e. g. for cup springs.

This model of a spring damper element is also available as a component, at which the spring and the damper is parameterized without look-up tables, so that linear characteristics can be computed, too (`SPRINGDAMPER`).

In addition, this model of a spring damper element summarizes the connections for the *stroke*, the *velocity* and the *force* in mechanical connector.

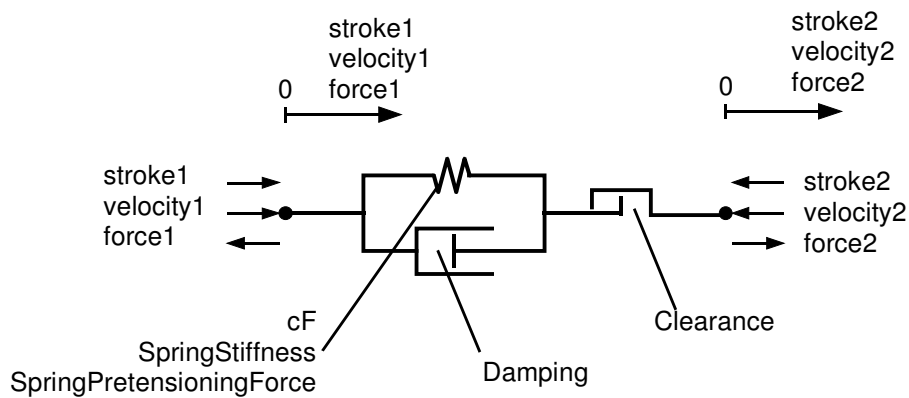
When the simulation starts, the input value for the look-up table is zero and independent from the initial *stroke1* and *stroke2*. The Pretensioning force is realized only with the *SpringforceCharacteristics*.

SpringDamperLoose



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Stroke1	In	mm	stroke of the connector 1
Stroke2	In	mm	stroke of the connector 2
Velocity1	In	m/s	velocity of connector 1
Velocity2	In	m/s	velocity of connector 2
Force1	Out	N	force applying at connector 1
Force2	Out	N	force applying at connector 2
cF	In	N/mm	additional spring stiffness
Mech1	Mech	-	mechanical Connector 1
Mech1F	In	N	Force at side 1
Mech1x	Out	Mm	Stroke
Mech1v	Out	m/s	Velocity
Mech2	Mech	-	mechanical Connector 2
Mech2F	In	N	Force at side 2
Mech2x	Out	Mm	Stroke
Mech2v	Out	m/s	Velocity

Parameters

Name	Value	Unit	Description
SpringStiffness	1	kN/mm	stiffness of the spring
Damping	1	kNs/m	velocity depending damping
Clearance	0	mm	clearance of the spring damper element
InitialStrokecompensation	1	-	Starting value consideration

Notes

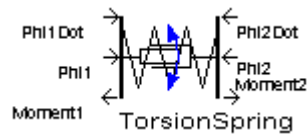
The component SPRINGDAMPERLOOSE is a model of a spring damper system with a clearance. The spring and the damper have linear characteristics. . The *SpringStiffness* can be varied by means of the connector cF.

The overall spring stiffness is the sum of the *SpringStiffness* +cF. There is no limitation used, that means that the overall spring stiffness could be negative

The component only works with stroke differences, not with absolute strokes. At the initial state, *Stroke 1* and *Stroke2* may have different values without any influence to the pre-tension of the spring. At the initial state the clearance is in middle position.

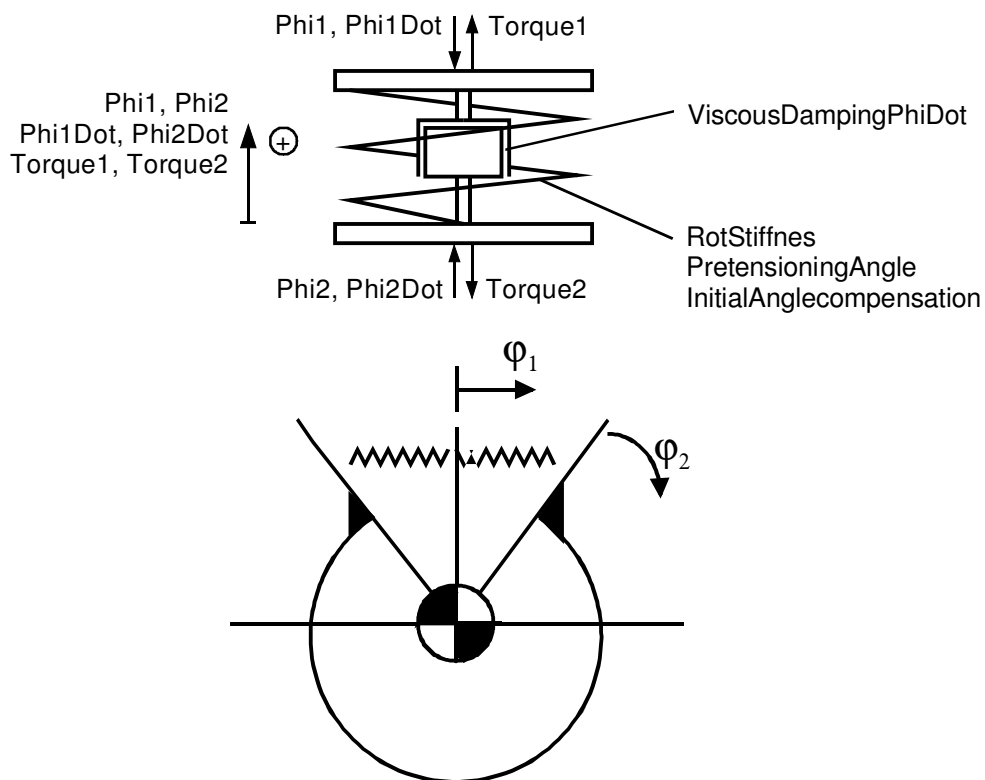
In addition, the model is also available as a component, which summarizes the connections for the *stroke*, the *velocity* and the *force* in mechanical connector.

TorsionSpring



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Phi1	In	deg	angle 1
Phi1Dot	In	deg/s	angle velocity 1
Phi2	In	deg	angle 2
Phi2Dot	In	deg/s	angle velocity 2
Torque1	Out	Nm	torque 1
Torque2	Out	Nm	torque 2
Mech1	Mech	-	rotary connector 1
Mech1M	In	Nm	Input moment
Mech1phi	Out	Rad	Rotation angle
Mech1omega	Out	rad/s	Angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	rotary connector 2
Mech2M	In	Nm	Input moment
Mech2phi	Out	Rad	Rotation angle
Mech2omega	Out	rad/s	Angular velocity

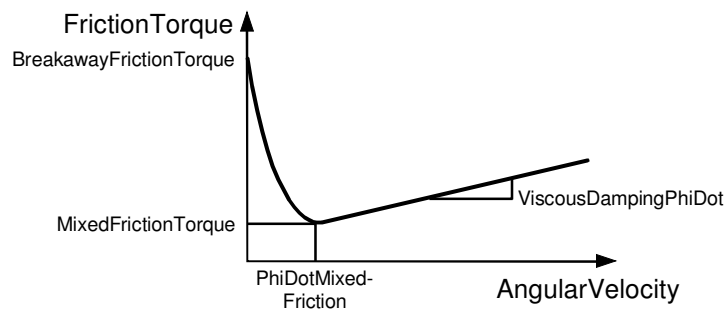
Parameters

Name	Value	Unit	Description
RotStiffness	1	Nm/deg	rotational stiffness of the spring
ViscousDampingPhiDot	0.1	Nms/deg	parameter for Stribeck-curve
PretensioningAngle	0	deg	Pretensioning angle of the spring
InitialAnglecompensation	1	-	Starting value consideration

Notes

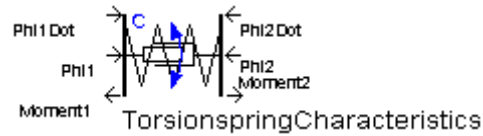
The component TORSIONSPRING is a model of a rotational spring damper system of which the spring and the damper have linear characteristics.

The parameter *ViscousDampingPhiDot* represents the characteristic values shown in the figure.



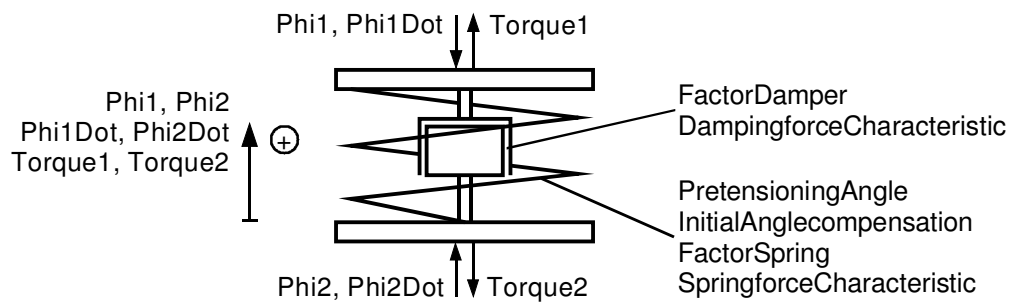
In addition, the model is available as a component, at which the connections are summarized for the *phi*, the *phidot*, and the *torque* in mechanical connector.

TorsionSpringCharacteristics



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Moment1	Mech	Kg m/s	Moment1
Phi1Dot	In	rad/s	Angularvelocity1
Phi1	In	-	Angle 1
Moment2	Mech	Kg m/s	Moment2
Phi2Dot	In	rad/s	Angularvelocity2
Phi2	In	-	Angle 2
Mech1	Mech	-	rotary connector 1
Mech1M	In	Nm	Input moment
Mech1phi	Out	Rad	Rotation angle
Mech1omega	Out	rad/s	Angular velocity
Mech2	Mech	-	rotary connector 2
Mech2M	In	Nm	Input moment
Mech2phi	Out	Rad	Rotation angle
Mech2omega	Out	rad/s	Angular velocity

Parameters

Name	Value	Unit	Description
PretensioningAngle	0	deg	Pretensioning angle of the spring
FactorSpring	1		Proportional factor of the <i>SpringforceCharacteristic</i>

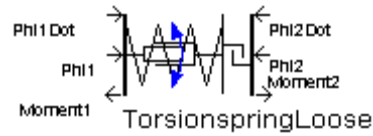
Name	Value	Unit	Description
FactorDamper	1		Proportional factor of the <i>DampingforceCharacteristic</i>
InitialAnglecompensation	0		Starting value consideration
SpringforceCharacteristic	-		Stroke dependent spring force characteristic
DampingforceCharacteristic	-		Velocity dependent damping force characteristic

Notes

The component TORSIONSPRINGCHARACTERISTICS is a model of a rotational spring damper system. Normally it is used with the ROTATIONALINERTIA – components to model multi-body-systems. The *PretensioningAngle* is setup separately, the spring- and the damper-forces are based on look-up tables.

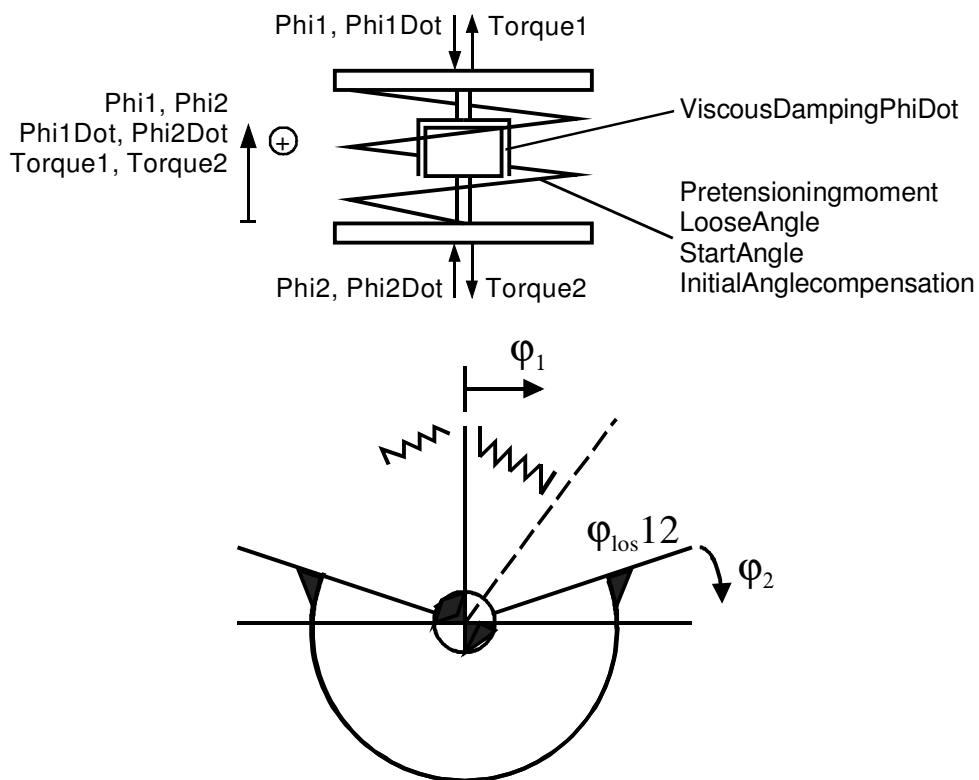
In addition, the model is available to summarize the connections for the *phi*, the *phidot*, and the *torque* in only one mechanical connector.

TorsionspringLoose



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Moment1	Mech	Kg m/s	Moment1
Phi1Dot	In	-	Angularvelocity1
Phi1	In	-	Angle 1
Moment2	Mech	Kg m/s	Moment2
Phi2Dot	In	-	Angularvelocity2
Phi2	In	-	Angle 2
Mech1	Mech	-	rotary connector 1
Mech1M	In	Nm	Input moment
Mech1phi	Out	Rad	Rotation angle
Mech1omega	Out	rad/s	Angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	rotary connector 2
Mech2M	In	Nm	Input moment
Mech2phi	Out	Rad	Rotation angle
Mech2omega	Out	rad/s	Angular velocity

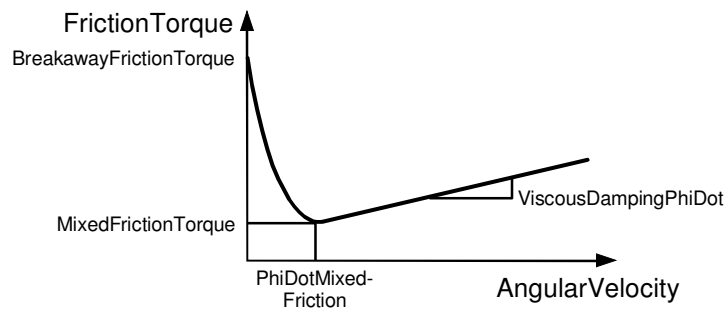
Parameters

Name	Value	Unit	Description
RotStiffness	1	Nm/deg	stiffness of the spring
ViscousDampingPhiDot	0.1	Nms/deg	characteristic for Stribeck curve
Pretensioningmoment	0	Nm	Pretensioning moment of the spring
LooseAngle	0	deg	Loose angle
StartAngle	0	deg	Starting angle
InitialAnglecompensation	1		Starting value consideration

Notes

The component TORSIONSPRINGCHARACTERISTICS is a model of a rotational spring damper system with a loose (*LooseAngle*) of which the spring and the damper have linear characteristics.

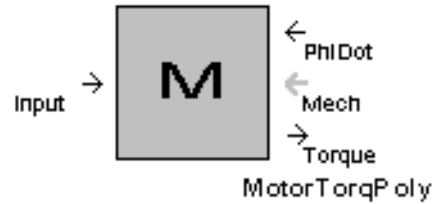
The parameter *ViscousDampingPhiDot* represents the characteristic values shown in the figure.



In addition, the model is available as a component, at which the connections are summarized for the *phi*, the *phidot*, and the *torque* in mechanical connector.

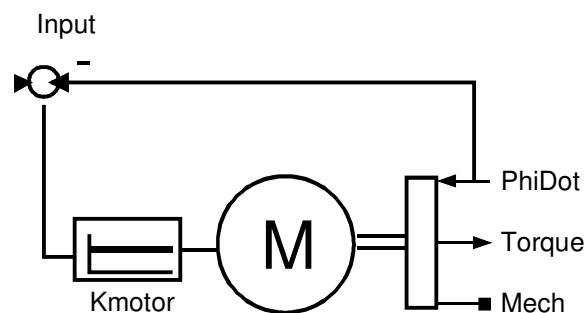
Drives

MotorTorqPoly



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque	Out	Nm	torque from the inertia
Input	In		input for the speed control
Mech	Mech	-	mechanical connection
MechM	In	Nm	torque generated by the motor
Mechphi	Out	rad	rotational angle
Mechomega	Out	rad/s	angular velocity
PhiDot	V	rad/s	angular acceleration

Parameters

Name	Value	Unit	Description
Omegamin	75	deg/s	minimum speed
Omegamax	240	deg/s	maximum speed
k3	9.0212e-6	-	Factor
k2	7.5153e-3	-	Factor
k1	1.5939	-	Factor

Name	Value	Unit	Description
k0	7.5022e+1	-	Factor
Kmotor	10	Nm/ (rad/s)	speed control factor

Notes

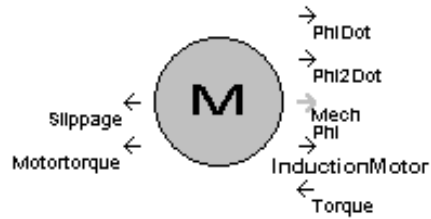
The component MOTORTORQPOLY is the model of a speed-controlled Diesel engine.

The maximum torque in dependence of the rotational speed is computed as a polynomial:

$$\begin{aligned}
 \text{Maximumtorque} = & \quad k0 \\
 & + k1 * \text{Mechomega} \\
 & + k2 * \text{Mechomega}^2 \\
 & + k3 * \text{Mechomega}^3
 \end{aligned}$$

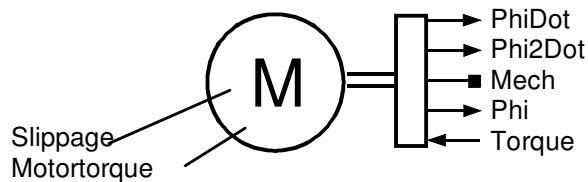
The factors $k0$ - $k3$ can be calculated from a known torque characteristic.

InductionMotor



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque	In	Nm	torque taking effect on the inertia
Motortorque	Out	Nm	torque generated by the motor
Phi	V	rad	angle
PhiDot	Out	rad/s	angular velocity
Phi2Dot	Out	rad/s	angular acceleration
RotSpeed	V	1/min	velocity of rotation
Mech	Mech	-	mechanical connection
MechM	In	Nm	torque generated by the motor
Mechphi	Out	rad	rotational angle
Mechomega	Out	rad/s	angular velocity
Slippage	Out	%	

Parameters

Name	Value	Unit	Description
Rated_power	37	KW	shown in data sheet
Rated_rot_speed	1450	1/min	rotation speed of the motor
Rated_frequency	50	Hz	power frequency

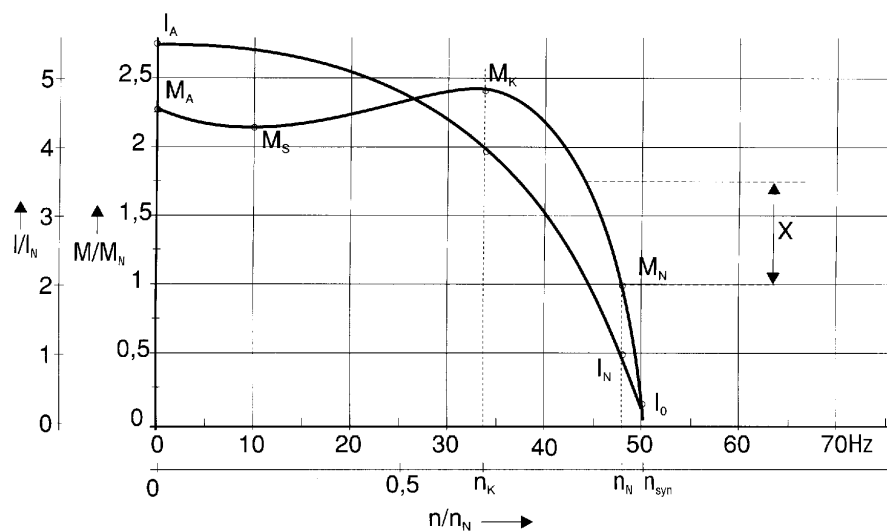
Name	Value	Unit	Description
StartingTorque	366	Nm	start of the torque
PullOuttorque	400	Nm	pull-out torque
PullOutrot_speed	0	1/min	pull-out rotational speed
Saddle_torque	300	Nm	saddle torque
Saddle_rot_speed	0	1/min	saddle rotation speed
Inertia	0.3680	Kgm ²	inertia of the motor

Notes

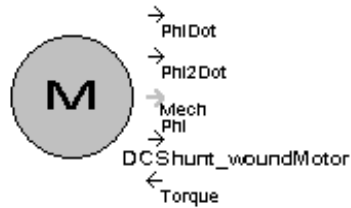
The component INDUCTIONMOTOR is a model of a squirrel-cage induction motor.

A fictitious characteristic is estimated from given parameters. The declaration of *Rated_power*, *Rated_rot_speed*, *Rated_frequency*, *StartingTorque* and *PullOuttorque* is required. The quality of the fictitious characteristic can be improved by declaration of further parameters as *PullOutrot_speed*, *Saddle_torque* and *Saddle_rot_speed*. Any unknown of these optional parameters have to be set to zero and are then estimated by the program.

When the parameters seem unusual, it can be indicated to compare the estimated characteristic with a typical torque characteristic of an induction motor as shown below.

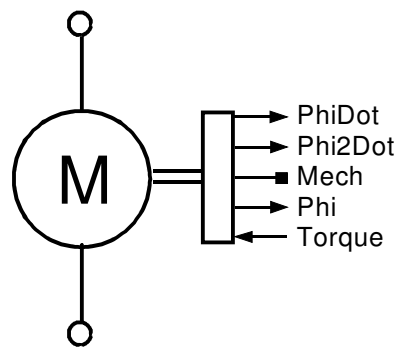


DCShunt_woundMotor



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque	In	Nm	torque taking effect on the inertia
Phi	V	rad	angle
PhiDot	V	rad/s	angular velocity
Phi2Dot	Out	rad/s	angular acceleration
Mech	Mech	-	mechanical connection
MechM	In	Nm	torque
Mechphi	Out	rad	angle
Mechomega	Out	rad/s	angular velocity

Parameters

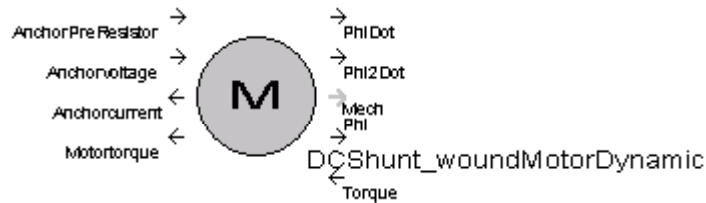
Name	Value	Unit	Description
Rated_power	4	kW	shown in data sheet
Rated_rot_speed	2400	1/min	shown in data sheet
Rated_voltage	420	V	shown in data sheet
Rated_current	10.9	A	shown in data sheet
Inertia	0.0153	Kgm ²	inertia of the motor

Name	Value	Unit	Description
TorqueLimitationAtStart	0	0 No 1 Yes	Limiting value of the torque at Starting
MStartToMRated	1.5		Torque factor from starting to rated

Notes

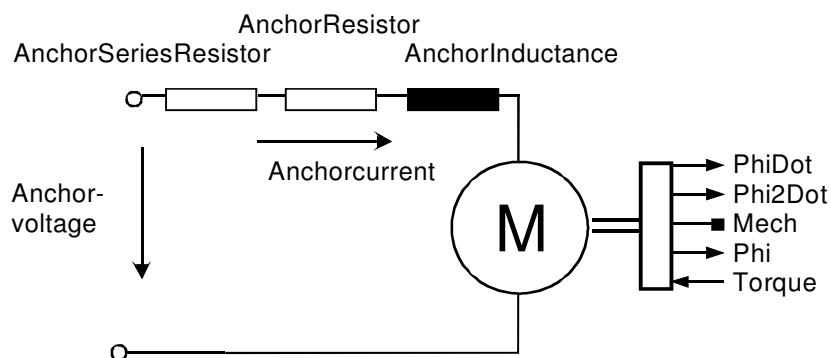
The component DCSHUNT_WOUNDMOTOR is a model of a direct-current shunt-wound motor considering inertia to simulate dynamical effects. It is possible to limit the torque at start to an efficient value.

DCShunt_woundMotorDynamic



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque	In	Nm	torque taking effect on the inertia
Motortorque	Out	Nm	torque generated by the motor
Phi	V	rad	angle
PhiDot	V	rad/s	angular velocity
Phi2Dot	Out	rad/s	angular acceleration
Mech	Mech	-	mechanical connection
MechM	In	Nm	torque generated by the motor
Mechphi	Out	rad	rotational angle
Mechomega	Out	rad/s	angular velocity
AnchorCircuitSeriesResistor	In	Ohm	Resistance value of the Anchor circuit
Anchorvoltage	In	V	terminal voltage
Anchorcurrent	Out	A	terminal current

Parameters

Name	Value	Unit	Description
Rated_power	4	kW	shown in data sheet
Rated_rot_speed	2400	1/min	shown in data sheet
Rated_voltage	420	V	shown in data sheet
Rated_current	10.9	A	
AnchorInductance	20.9	mH	
Inertia	0.0153	Kgm ²	inertia of the motor

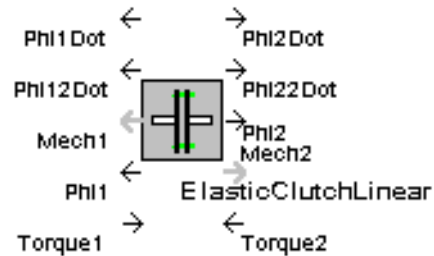
Notes

The component DCSHUNT_WOUNDMOTORDYN is a model of a direct-current shunt-wound motor which considers not only inertia but also electromechanical time constants, so that no torque limitation at start is needed.

With the variable AnchorCurcuitSeriesResistor the simulation of a speed control is possible. The resistance of the anchor itself is computed from the given parameters.

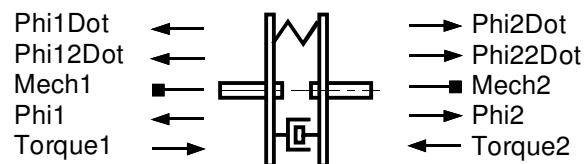
Clutches and Brakes

ElasticClutchLinear



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity

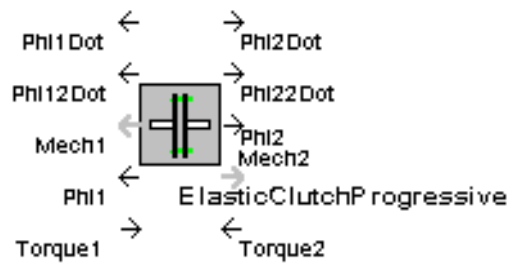
Parameters

Name	Value	Unit	Description
Springstiffness	30	N/deg	Stiffness of the Spring
Inertia1	1e-3	kgm ²	Inertia at the clutch side 1
Inertia2	1e-3	kgm ²	Inertia at the clutch side 2
DeltaPhilimited	1	0 / 1	Limited change in the rotational angle
DeltaPhiMax	3.5	deg	Maximum change in the rotational angle
PreStressAngle	0.	deg	Angle at which prestress occurs
RelatedDamping	0.1	Nms/deg	Damping value

Notes

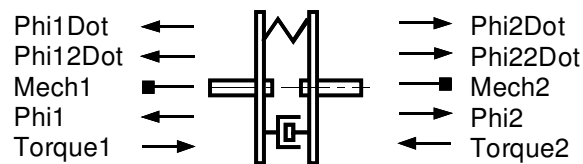
The component ELASTICCLUTCHLINEAR is a model of an elastic clutch considering inertia, stiffness, damping and an optional pre-stress angle. The maximum twisting angle can be limited to *DeltaPhiMax* by setting *DeltaPhilimited* to 1.

ElasticClutchProgressive



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque 2	In	Nm	torque taking effect on inertia 2
Phi1	Aus	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity

Parameters

Name	Value	Unit	Description
DeltaPhiLimited	1	0 / 1	Limited change in the twisting angle
DeltaPhiMax	3	deg	Maximum change in the twisting angle
ExponentLimitFct	5	-	Factor, determining the stiffness of the stop
Inertia1	1e-3	kgm ²	Inertia at the clutch side 1
Inertia2	1e-3	kgm ²	Inertia at the clutch side 2
RelatedDamping	0.1	Nms/deg	Damping value
Exponent	1	-	Exponent value
Phi0	1	deg	Starting angle
TorquePhi0lin	25	Nm	Linear torque value at the Starting position
TorquePhi0exp	50	Nm	Exponential torque value at the Starting position
PreStressAngle	0	deg	Pre stress angle

Notes

The component **ELASTICCLUTCHPROGRESSIVE** is a model of an elastic clutch with inertia and a stiffness characteristic consisting of a linear and a exponential part. According to the actual stiffness, the damping is computed using the parameter *RelatedDamping*.

The maximum twisting angle can be limited to *DeltaPhiMax*, the value of *ExponentLimitFct* determines the stiffness of the stop.

The parameters *Exponent*, *Phi0*, *Phi1*, *TorquePhi0lin*, und *TorquePhi0exp* have to be found from the clutch characteristic.

First you have to draw the zero point tangent.

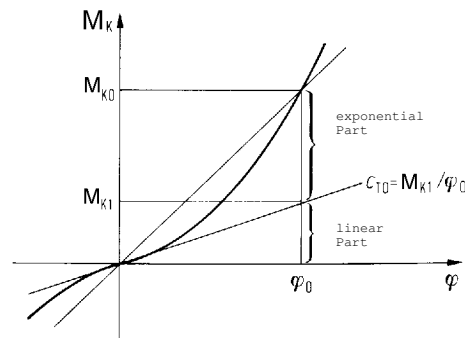
If the gradient = 0 or if there is fetch in the characteristic line the clutch parameters are not specified in an offhand way. Because of the calculation method which requires a tangent gradient > 0, the straight line has to be defined as plane as possible.

The gradient of the initial tangent has not to be necessary exactly the same as the measured initial gradient. It is more important that the basic approach, which contents both the linear and the exponential part, approximates as near as possible at the measured characteristic line.

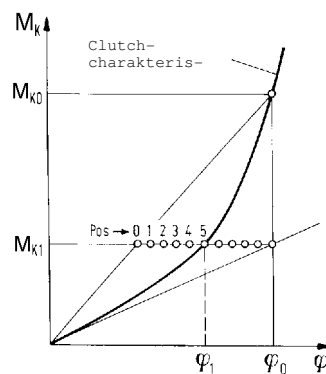
A straight line which parallels the abscissa has to be construed through the point *TorquePhi0lin* (M_{K1}). *TorquePhi0lin* is a multiple of the *NominalTorques*, favored 2 but also 3 or 5, whereas a proportion has to be chosen in which the characteristic line is described at best.

If the gradient of the tangent = 0, the angle according to *Phi0*, for which the proportion *TorquePhi0exp*(M_{K0}) / *TorquePhi0lin*(M_{K1}) = 3; 2 or 1, 5, has to be decided.

Proportion 3 has to be chosen to get the tangent with the lowest gradient.



If the gradient of the characteristic line has in the rise a value > 0 , the angle according to *Phi0* results from the intersection of the straight lines through the *TorquePhi0lin* (M_{K1}) and the tangent. The intersection of the perpendicular through *Phi0* with the characteristic line results in the *TorquePhi0exp*(M_{K0}). The angle for which the characteristic line has the value *TorquePhi0lin*(M_{K1}) is *Phi1*.



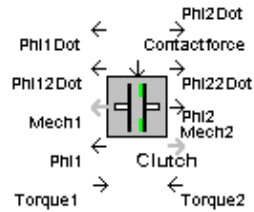
Now, the *Exponent* can be computed with the equation

$$Exponent = \frac{\log\left(1 - \frac{\Phi_{11}}{\Phi_{10}}\right) - \log\left(\frac{TorquePhi0exp}{TorquePhi0lin} - 1\right)}{\log\left(\frac{\Phi_{11}}{\Phi_{10}}\right)}$$

To assess the exponent a straight line can be drawn through the origin and the point of the characteristic line, for which the value is *TorquePhi0exp* (M_{K0}).

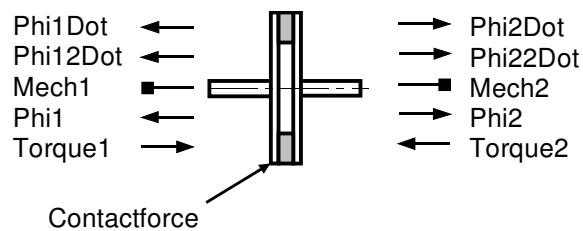
The determination of the exponent then can be carried out as indicated in the picture: The horizontal through M_{K1} is divided into ten parts between the shown intersection points. Then the exponent could be read from the characteristic line.

Clutch



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque 2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by the motor
Mech2phi	Out	rad	rotational angle
Mech2omega	Out	rad/s	angular velocity
ContactForce	In	N	ActuatingForce

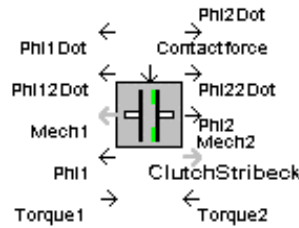
Parameters

Name	Value	Unit	Description
Rated_torque	50	Nm	Nominal torquevalue
No_Loadtorque	1	Nm	Torque value at no load condition
ContactForceMaximum	1	N	ContactForce for Nominal-Torque
Inertia1	1e-3	kgm ²	Inertia of the clutch at side1
Inertia2	1e-3	kgm ²	Inertia of the clutch at side2

Notes

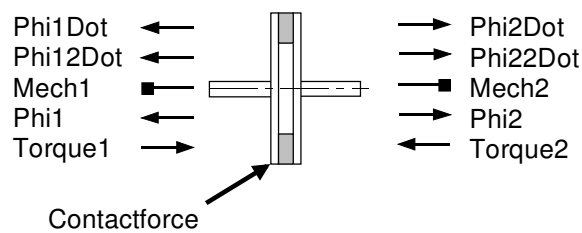
The component CLUTCH is a model of a clutch with torque transmission by friction, the inertia is taken into consideration. For a *ContactForce* less or equal zero *No_Loadtorque* is transmitted, a *ContactForce* greater or equal to *ContactForceMaximum* causes transmission of *Rated_torque*. For a *ContactForce* between these borders the transmitted torque follows a linear function.

ClutchStribeck



Symbol

Sketch



Connectors and Variables

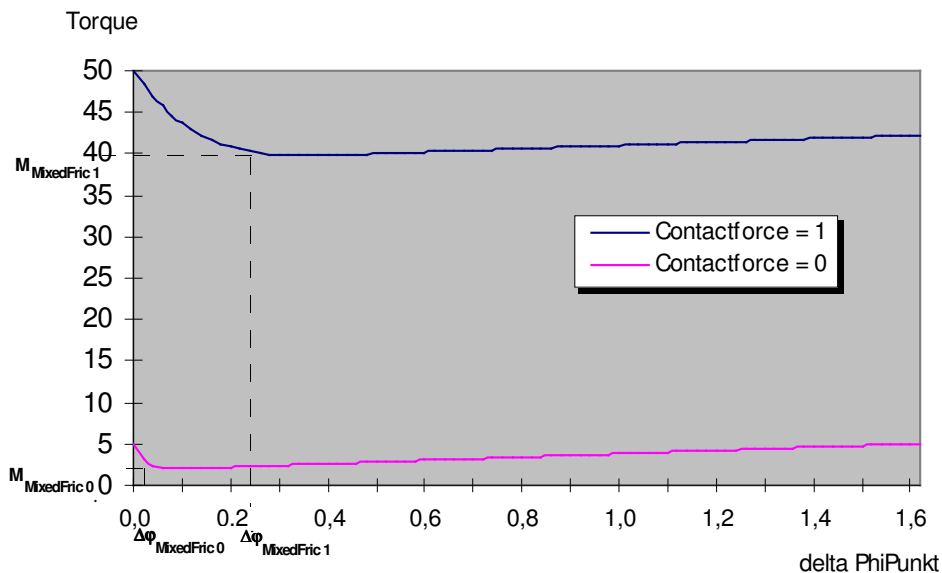
Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by the motor
Mech2phi	Out	rad	rotational angle
Mech2omega	Out	rad/s	angular velocity
ContactForce	In	N	ActuatingForce

Parameters

Name	Value	Unit	Description
NominalTorque	50	Nm	Operating torque
No_LoadBreakawaytorque	3	Nm	Reakaway torque at no load
ContactForceMaximum	1	N	ContactForce for Nominal-Torque
Inertia1	1e-3	kgm ²	Inertia at the clutch side 1
Inertia2	1e-3	kgm ²	Inertia at the clutch side2
ViscousDampingPhiDot	0.01	Nms/deg	characteristic for Stribeck curve
MixedFrictionTorque1	35	Nm	characteristic for Stribeck curve
MixedFrictionTorque0	1	Nm	characteristic for Stribeck curve
PhiDotMixedFriction1	50	deg/s	characteristic for Stribeck curve
PhiDotMixedFriction0	5	deg/s	characteristic for Stribeck curve

Notes

The component CLUTCHSTRIBECK is a model of a clutch with friction according to a Stribeck curve like given in wet clutches. Inertia is taken into consideration.

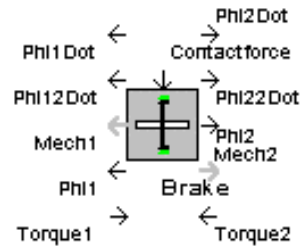


For a *ContactForce* less or equal zero the transmitted torque follows the lower Stribeck curve (index 0), a *ContactForce* greater or equal to *ContactForceMaximum* causes transmission of a torque according to the upper curve (index 1). The Stribeck curves are generated from the parameters *MixedFrictionTorque*, *PhiDotMixedFriction* and *ViscousDampingPhiDot*.

For a *ContactForce* greater or equal the *ContactForceMaximum* the Stribeck curve results from the points *NominalTorque* for which delta *PhiDot* is zero, *MixedFrictionTorque1* at *PhiDotMixedFriction* and *ViscousDampingPhiDot* as slope of the *FrictionCurve* above a rotational speed difference from *PhiDotMixedFriction*.

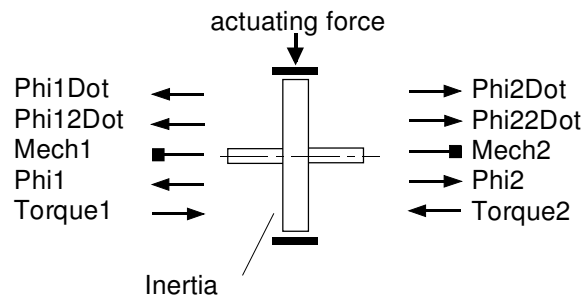
For a *ContactForce* between these borders the transmitted torque follows a Stribeck curve computed from linear interpolated parameters.

Brake



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity
ContactForce	In	N	brake ActuatingForce

Parameters

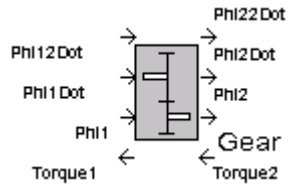
Name	Value	Unit	Description
Rated_torque	50	Nm	maximum brake torque
ContactForceMaximum	1	N	ContactForce for Nominal-Torque
Inertia	1e-3	kgm ²	brake inertia

Notes

The component BRAKE is a model of a brake with inertia, the braking torque varies between zero and *Rated_torque* according to the actual ActuatingForce.

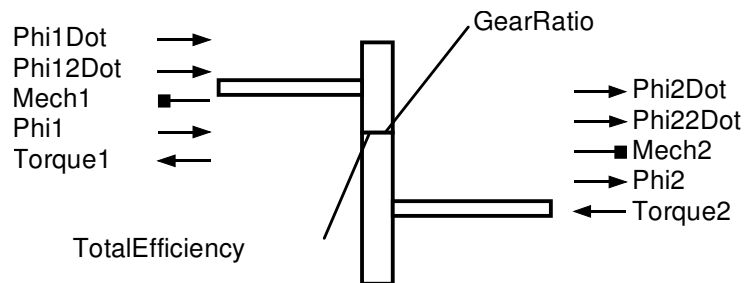
Gears

Gear



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity

Parameters

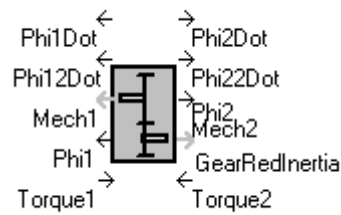
Name	Value	Unit	Description
GearRatio	2	-	Ratio of the teeth between the driver and driven gear
TotalEfficiency	98	%	Efficiency of the gear drive

Notes

The component GEAR is a model of a gear with no inertia and fixed transmission ratio. losses can be considered with the parameter *TotalEfficiency*.

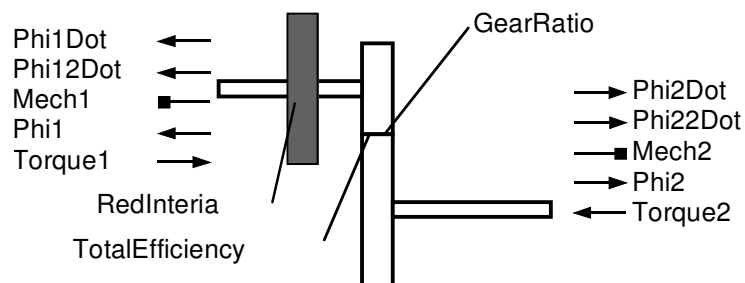
$$\begin{aligned} \text{GearRatio} &= \Phi_1 / \Phi_2 \\ &= \dot{\Phi}_1 / \dot{\Phi}_2 \\ &= \dot{\Phi}_{12} / \dot{\Phi}_{22} \end{aligned}$$

GearRedInertia



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity

Parameters

Name	Value	Unit	Description
RedInertia	1	kgm ²	RedInertia
GearRatio	2	-	Ratio of the teeth between the driver and driven gear
TotalEfficiency	98	%	Efficiency of the gear
CenterDistance	60	mm	distance between the centers of Driver and Driven gears
Modul	1	mm	Space between two teeth
HelicalAngle	0	deg	Angle of the helical teeth

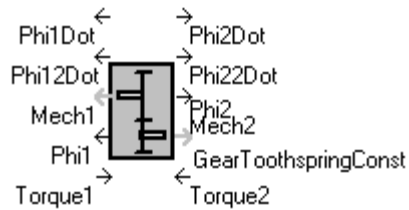
Notes

The component GEARREDINERTIA is a model of a simple gear with fixed transmission ratio. Losses can either be considered with the parameter *Total Efficiency* or be computed with the parameters *CenterDistance*, *Modul* and *HelicalAngle* when *Total Efficiency* is set to zero.

To simulate dynamical effects, the inertia can be given as on the drive shaft reduced inertia *RedInertia*.

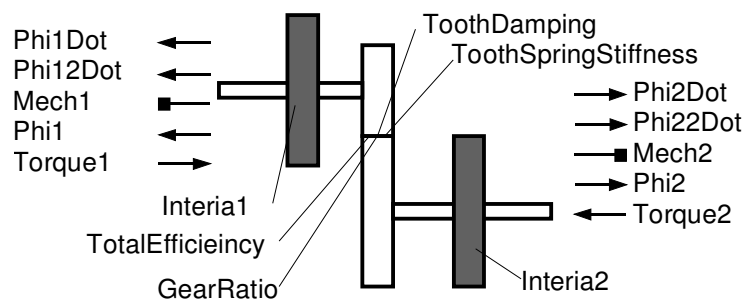
$$\begin{aligned}
 \text{GearRatio} &= \Phi_1 / \Phi_2 \\
 &= \dot{\Phi}_1 / \dot{\Phi}_2 \\
 &= \dot{\Phi}_{12} / \dot{\Phi}_{22}
 \end{aligned}$$

GearToothspringConst



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia 1
Torque2	In	Nm	torque taking effect on inertia 2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by
Mech2phi	Out	rad	the motor
Mech2omega	Out	rad/s	rotational angle
			angular velocity

Parameters

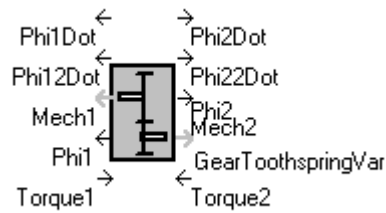
Name	Value	Unit	Description
GearRatio	2	-	Ratio of the teeth between the driver and driven gear
CenterDistance	60	mm	distance between the centers of Driver and Driven gears
Inertia1	0.001	kgm ²	Inertia at the gear 1
Inertia2	0.001	kgm ²	Inertia at the gear 2
SingleSpringStiffness	14000	N/mm	SpringStiffness
EngagementSpringStiffness	20000	N/mm	SpringStiffness during Engage
Toothdamping	0	kNs/m	Damping of the gear
Modul	2	mm	Space between the teeth
HelicalAngle	0	deg	Angle of the helical teeth
TotalEfficiency	0.99	-	Efficiency of the gear
TotalOverlap	1.5	-	Overlap of Driving and driven gears
Profileshiftingfactor1	0.2	-	
Profileshiftingfactor2	-0.2	-	
Gearbodyfactor	1	-	
Gearwidth	0	mm	Width of the gear
Gearrimthickness	0	mm	Gearrimthickness
Stegbreite	0	mm	Stegbreite
Referenceprofilefactor	1	-	Profile factor for particular standard value
AngleofAction	20	deg	The angle at which the gear starts move
Dedendum1	1	mm	depth of a tooth space below the pitch line
Dedendum2	1	mm	depth of a tooth space below the pitch line

Notes

The component GEARTOOTHSPRINGCONST is a model of a gear with fixed transmission ratio considering constant stiffness and damping of the teeth after DIN 3990 method B or C.

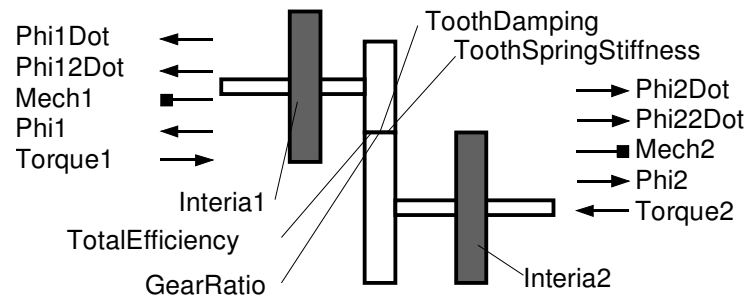
$$\begin{aligned} \text{GearRatio} &= \Phi_1/\Phi_2 = \dot{\Phi}_1/\dot{\Phi}_2 \\ &= \dot{\Phi}_{12}/\dot{\Phi}_{22} \end{aligned}$$

GearToothspringVar



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Torque1	In	Nm	torque taking effect on inertia1
Torque2	In	Nm	torque taking effect on inertia2
Phi1	Out	rad	angle
Phi1Dot	Out	rad/s	angular velocity
Phi12Dot	Out	rad/s ²	angular acceleration
Phi2	Out	rad	angle
Phi2Dot	Out	rad/s	angular velocity
Phi22Dot	Out	rad/s ²	angular acceleration
Mech1	Mech	-	mechanical connection 1
Mech1M	In	Nm	torque generated by the motor
Mech1phi	Out	rad	rotational angle
Mech1omega	Out	rad/s	angular velocity

Name	Type	Unit	Description
Mech2	Mech	-	mechanical connection 2
Mech2M	In	Nm	torque generated by the motor
Mech2phi	Out	rad	rotational angle
Mech2omega	Out	rad/s	angular velocity

Parameters

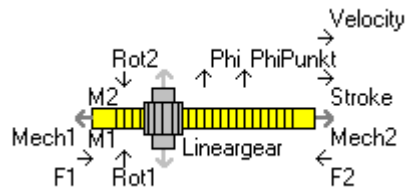
Name	Value	Unit	Description
GearRatio	2	-	Ratio of the teeth between the driver and driven gear
CenterDistance	60	mm	distance between the centers of Driver and Driven gears
Inertia1	1e-3	kgm ²	Inertia at the gear 1
Inertia2	1e-3	kgm ²	Inertia at the gear 2
SingleSpringStiffness	20000	N/mm	SpringStiffness
Toothdamping	0	kNs/m	Damping of the gear
Modul	2	mm	Space between the teeth
HelicalAngle	0	deg	Angle of the hellical teeth
TotalEfficiency	0.99	-	Efficiency of the gear
TotalOverlap	1.5	-	Overlap of Driving and driven gears
Profileshiftingfactor1	0.2	-	
Profileshiftingfactor2	-0.2	-	
Gearbodyfactor	1	-	
Gearwidth	0	mm	Width of the gear
Gearrimthickness	0	mm	Gearrimthickness
Stegbreite	0	mm	Stegbreite
Referenceprofilefactor	1	-	Profile factor for particular standard value
AngleofAction	20	deg	The angle at which the gear starts move
Dedendum1	1	mm	depth of a tooth space below the pitch line
Dedendum2	1	mm	depth of a tooth space below the pitch line

Notes

The component GEARTOOTHSPRINGVAR is a model of a gear with fixed transmission ratio considering stiffness and damping of the teeth according to the actual rotational angle after DIN 3990 method B or C.

$$\begin{aligned}\text{GearRatio} &= \Phi_1/\Phi_2 \\ &= \dot{\Phi}_1/\dot{\Phi}_2 \\ &= \dot{\Phi}_{12}/\dot{\Phi}_{22}\end{aligned}$$

Lineargear



Symbol

Sketch

Connectors and Variables

Name	Type	Unit	Description
Mech1	Mech	-	linear connector to Lineargear 1
Mech1F	In	N	force applying to the Lineargear 1
Mech1x	Out	mm	shift of the Lineargear 1 towards the direction of force 1
Mech1v	Out	m/s	velocity of the Lineargear 1 towards the direction of force 1
Mech2	Mech	-	linear connector to Lineargear 2
Mech2F	In	N	force applying to the Lineargear 2
Mech2x	Out	Mm	shift of the Lineargear 2 towards the direction of force 2
Mech2v	Out	m/s	velocity of the Lineargear 2 towards the direction of force 2
Rot1	Mech	-	rotational connector to the Lineargear system
Rot1M	In	Nm	torque
Rot1phi	Out	Rad	angle
Rot1omega	Out	rad/s	angular velocity
Phi	V	rad	angle (internal auxiliary

Name	Type	Unit	Description
			variable)
PhiDot	V	rad/s	angular velocity (internal auxiliary variable)
M1	In	Nm	Torque 1
M2	In	Nm	Torque 2
F1	In	N	External Force1
F2	In	N	External Force2

Parameter

Name	Value	Unit	Description
Mass	100	kg	Mass of the linear gear
Inertia	0.001	kgm ²	Inertia of the rotational mass
Ratio	30	mm/rev	Ratio of the driver and driven gear
Efficiency	95	%	Gear efficiency
Orientation	0	deg	angle between the movement plane and the horizontal plane

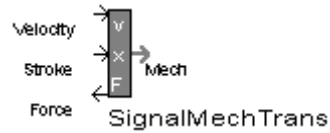
Notes

The component LINEARGEAR is a model of a rack-and-pinion gear with two different effect directions.

By skewing LINEARGEAR serves for the orientation of the weight force.

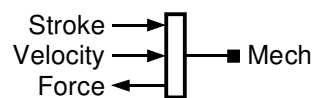
Miscellaneous

SignalMechTrans



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Stroke	In	mm	stroke
Velocity	In	m/s	velocity
Force	Out	N	force
Mech	Mech	-	mechanical connector
Mechx	Out	mm	stroke
Mechv	Out	m/s	velocity
MechF	In	N	force

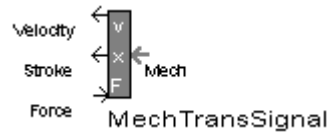
Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

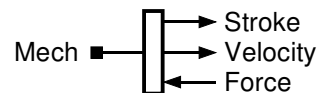
The component SIGNALMECHTRANS summarizes the signal connectors *Stroke*, *Velocity*, and *Force* to the mechanical connector *Mech*.

MechTransSignal



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Stroke	Out	mm	stroke
Velocity	Out	m/s	velocity
Force	In	N	force
Mech	Mech	-	mechanical connector
Mechx	In	mm	stroke
Mechv	In	m/s	velocity
MechF	Out	N	force

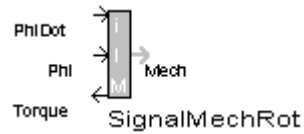
Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

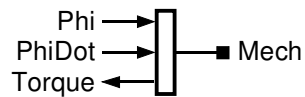
The component MECHTRANSIGNAL divides the mechanical connector *Mech* into the signal connectors *Stroke*, *Velocity*, and *Force*.

SignalMechRot



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Phi	In	deg	angle
PhiDot	In	deg/s	angular velocity
Torque	Out	Nm	moment
Mech	Mech	-	mechanical connector
Mechphi	Out	deg	angle
Mechomega	Out	deg/s	angular velocity
MechM	In	Nm	torque

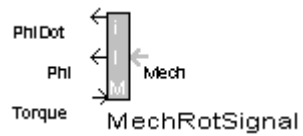
Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

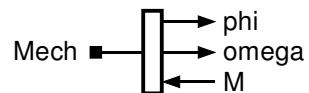
The component SIGNALMECHROT summarizes the signal connectors *phi*, *omegay*, and *M* to the mechanical connector *Mech*.

MechRotSignal



Symbol

Sketch



Connectors and Variables

Name	Type	Unit	Description
Phi	Out	deg	angle
Omega	Out	deg/s	angular velocity
M	In	Nm	torque
Mech	Mech	-	mechanical connector
Mechphi	In	deg	angle
Mechomega	In	deg/s	angular velocity
MechM	Out	Nm	torque

Parameters

Name	Value	Unit	Description
-	-	-	-

Notes

The component MechRotSignal divides the mechanical connector Mech into the signal connectors phi, omega, and M.