Valve42

In[310]:= **<< C:\\Hopsan\Compgen\CompgenNG.mx**

This path is pointing to where the file should be generated

H:\PettersDropbox\Dropbox\HopsanComponents\PneumaticDevelop\PneumaticComponents\

In[311]:= **path = ToFileName[{"C:", "Users", "petkr14", "Dropbox",**
"HopsanComponents", "PneumaticDevelop", "PneumaticComponents"}];

In[312]:= **path = ToFileName[{"H:", "PettersDropbox", "Dropbox",**
"HopsanComponents", "PneumaticDevelop", "PneumaticComponents"}];

domain = "Pneumatic";
displayName = "Valve42";
brief = "Pneumatic 42-valve";
componentType = "ComponentQ";
author = "Petter Krus*<petter.krus@liu.se>,
Victor Juliano De Negri <victor.de.negri@ufsc.br>";**
affiliation = "*IEI/Flumes, Linköping University, **Universidade
Federal de Santa Catarina";
SetFilenames[path, domain, displayName];
ResetComponentVariables[];
Date[]

Component description

This is a simple pneumatic valve with three ports and three positions. It opens between pressure port (1) and load port (2) and between the load port (4) and return (3) when the input signal it is one. The opening is proportional to the input signal. At zero input signal it opens the load port (2) to the return port (3) and between the pressure port (1) and load port (4). The opening is proportional to the input signal. There is no valve dynamics
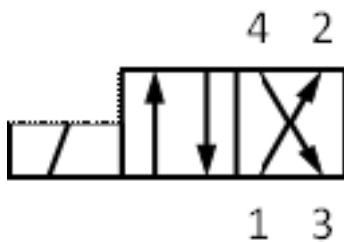
In[323]:= **inputParameters = {**
{Bf, .528, double, "", "B, ISO critical pressure ratio"},
{Cf, 1. × 10^{-13}, double, "", "C, ISO flow coefficient"},
{x0, 0.1, double, "", "Relative overlap"},
{p0, 100000., double, "Pa", "Nominal pressure"},
{T0, 297., double, "K", "Nominal temperature"},
{R, 287., double, "J/Kg K", "Gas constant"},
{cv, 718, double, "J/Kg K", "heatcoeff"},
{eps, 0.02, double, "", "Linearisation coeff"}
};

```
In[324]:= inputVariables = {
          {xin, 1, double, "", "Input signal 0<xin<1"}
        };
```

```
In[325]:= outputVariables = {
          {qm12Pos, 0., double, "kg/s", "Internal variable"},
          {qm12Neg, 0., double, "kg/s", "Internal variable"},
          {qm32Pos, 0., double, "kg/s", "Internal variable"},
          {qm32Neg, 0., double, "kg/s", "Internal variable"},
          {qm14Pos, 0., double, "kg/s", "Internal variable"},
          {qm14Neg, 0., double, "kg/s", "Internal variable"},
          {qm34Pos, 0., double, "kg/s", "Internal variable"},
          {qm34Neg, 0., double, "kg/s", "Internal variable"},
          {Ng32e, 0., double, "", "Internal variable"},
          {Ng12e, 0., double, "", "Internal variable"},
          {Ng34e, 0., double, "", "Internal variable"},
          {Ng14e, 0., double, "", "Internal variable"},
          {Bfe, 0., double, "", "Internal variable"}
        };
```

```
In[326]:= nodeConnections = {
          PneumaticQnode[1, 100000., "fluid port 1 (P)"],
          PneumaticQnode[2, 100000., "fluid port 2 (A)"],
          PneumaticQnode[3, 100000., "fluid port 3 (R)"],
          PneumaticQnode[4, 100000., "fluid port 4 (B)"]
        };
```

The system of equations

The spool position is recalculated.

```
In[327]:= xine = 2 xin - 1;
```

The valve areas are limited between 0 and A1max and A3max respectively .

```
In[328]:= Cf12 = Cf limit[ ( (xine - x0) / (1 - x0) ), 0, 1];

       Cf32 = Cf limit[ ( (-xine - x0) / (1 - x0) ), 0, 1];

       Cf14 = Cf limit[ ( (-xine - x0) / (1 - x0) ), 0, 1];

       Cf34 = Cf limit[ ( (xine - x0) / (1 - x0) ), 0, 1];
```

```
In[332]:= Bf12 = Bf;
       Bf32 = Bf;
       Bf14 = Bf;
       Bf34 = Bf;
```

Calculation of the Ng functions for flow calculations.

```
In[336]:= Ng1 = 1;
```

$$
In[337]:= \text{Ng12Pos} := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p2}{p1} - Bf12 \right)^2}{\left(1 - Bf12 \right)^2}, \text{eps} \right] \right)
$$

In[338]:= `Ng12Neg :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p1}{p2} - Bf12 \right)^2}{\left(1 - Bf12 \right)^2}, \text{eps} \right] \right)$

In[339]:= `Ng12 := onPositive[p1 - p2]` $\left(\text{onPositive} \left[\frac{p2}{p1} - Bf12 \right] \text{Ng12Pos} + \text{onNegative} \left[\frac{p2}{p1} - Bf12 \right] \text{Ng1} \right) +$
$\text{onNegative}[p1 - p2] \left(\text{onPositive} \left[\frac{p1}{p2} - Bf12 \right] \text{Ng12Neg} + \text{onNegative} \left[\frac{p1}{p2} - Bf12 \right] \text{Ng1} \right);$

In[340]:= `Ng32Pos :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p2}{p3} - Bf32 \right)^2}{\left(1 - Bf32 \right)^2}, \text{eps} \right] \right)$

In[341]:= `Ng32Neg :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p3}{p2} - Bf32 \right)^2}{\left(1 - Bf32 \right)^2}, \text{eps} \right] \right)$

In[342]:= `Ng32 := onPositive[p3 - p2]` $\left(\text{onPositive} \left[\frac{p2}{p3} - Bf32 \right] \text{Ng32Pos} + \text{onNegative} \left[\frac{p2}{p3} - Bf32 \right] \text{Ng1} \right) +$
$\text{onNegative}[p3 - p2] \left(\text{onPositive} \left[\frac{p3}{p2} - Bf \right] \text{Ng32Neg} + \text{onNegative} \left[\frac{p3}{p2} - \text{crit} \right] \text{Ng1} \right);$

In[343]:= `Ng14Pos :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p4}{p1} - Bf14 \right)^2}{\left(1 - Bf14 \right)^2}, \text{eps} \right] \right)$

In[344]:= `Ng14Neg :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p1}{p4} - Bf14 \right)^2}{\left(1 - Bf14 \right)^2}, \text{eps} \right] \right)$

In[345]:= `Ng14 := onPositive[p1 - p4]` $\left(\text{onPositive} \left[\frac{p4}{p1} - Bf14 \right] \text{Ng14Pos} + \text{onNegative} \left[\frac{p4}{p1} - Bf14 \right] \text{Ng1} \right) +$
$\text{onNegative}[p1 - p4] \left(\text{onPositive} \left[\frac{p1}{p4} - Bf14 \right] \text{Ng14Neg} + \text{onNegative} \left[\frac{p1}{p4} - Bf14 \right] \text{Ng1} \right);$

In[346]:= `Ng34Pos :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p4}{p3} - Bf34 \right)^2}{\left(1 - Bf34 \right)^2}, \text{eps} \right] \right)$

In[347]:= `Ng34Neg :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p3}{p4} - Bf34 \right)^2}{\left(1 - Bf34 \right)^2}, \text{eps} \right] \right)$

In[348]:= `Ng34 := onPositive[p3 - p4]` $\left(\text{onPositive} \left[\frac{p4}{p3} - Bf34 \right] \text{Ng34Pos} + \text{onNegative} \left[\frac{p4}{p3} - Bf34 \right] \text{Ng1} \right) +$
$\text{onNegative}[p3 - p4] \left(\text{onPositive} \left[\frac{p3}{p4} - Bf34 \right] \text{Ng34Neg} + \text{onNegative} \left[\frac{p3}{p4} - Bf34 \right] \text{Ng1} \right);$

New equations

In[349]:= `Ng1 = 1;`

`Ng12Pos :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p2}{p1} - \text{crit} \right)^2}{\left(1 - \text{crit} \right)^2}, \text{eps} \right] \right)$

`Ng12Neg :=` $\left(\text{signedSquareL} \left[1 - \frac{\left(\frac{p1}{p2} - \text{crit} \right)^2}{\left(1 - \text{crit} \right)^2}, \text{eps} \right] \right)$

`Ng12 :=`

$$\text{onPositive}[p1 - p2] \left(\text{onPositive}\left[\frac{p2}{p1} - Bf12 \right] Ng12Pos + \text{onNegative}\left[\frac{p2}{p1} - Bf12 \right] Ng1 \right) +$$
$$\text{onNegative}[p1 - p2] \left(\text{onPositive}\left[\frac{p1}{p2} - Bf12 \right] Ng12Neg + \text{onNegative}\left[\frac{p1}{p2} - Bf12 \right] Ng1 \right);$$

$$Ng32Pos := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p2}{p3} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng32Neg := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p3}{p2} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng32 :=$$
$$\text{onPositive}[p3 - p2] \left(\text{onPositive}\left[\frac{p2}{p3} - crit \right] Ng32Pos + \text{onNegative}\left[\frac{p2}{p3} - Bf32 \right] Ng1 \right) +$$
$$\text{onNegative}[p3 - p2] \left(\text{onPositive}\left[\frac{p3}{p2} - crit \right] Ng32Neg + \text{onNegative}\left[\frac{p3}{p2} - Bf32 \right] Ng1 \right);$$

$$Ng14Pos := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p4}{p1} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng14Neg := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p1}{p4} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng14 :=$$
$$\text{onPositive}[p1 - p4] \left(\text{onPositive}\left[\frac{p4}{p1} - Bf14 \right] Ng14Pos + \text{onNegative}\left[\frac{p4}{p1} - Bf14 \right] Ng1 \right) +$$
$$\text{onNegative}[p1 - p4] \left(\text{onPositive}\left[\frac{p1}{p4} - Bf14 \right] Ng14Neg + \text{onNegative}\left[\frac{p1}{p4} - Bf14 \right] Ng1 \right);$$

$$Ng34Pos := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p4}{p3} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng34Neg := \left(\text{signedSquareL}\left[1 - \frac{\left(\frac{p3}{p4} - crit \right)^2}{(1 - crit)^2}, eps \right] \right)$$

$$Ng34 :=$$
$$\text{onPositive}[p3 - p4] \left(\text{onPositive}\left[\frac{p4}{p3} - crit \right] Ng34Pos + \text{onNegative}\left[\frac{p4}{p3} - crit \right] Ng1 \right) +$$
$$\text{onNegative}[p3 - p4] \left(\text{onPositive}\left[\frac{p3}{p4} - crit \right] Ng34Neg + \text{onNegative}\left[\frac{p3}{p4} - crit \right] Ng1 \right);$$

Equations

In[350]:= `localExpressions = {`

$$\text{kappa} == 1 + \frac{R}{cv},$$

$$\text{Kg} == \sqrt{\frac{2^{\frac{kappa+1}{kappa-1}} \, kappa \left(\frac{1}{kappa+1}\right)^{\frac{kappa+1}{kappa-1}}}{R}},$$

$$\text{Ndenom} == 2^{\frac{kappa+1}{kappa-1}-1} \, (kappa - 1) \left(\frac{1}{kappa + 1}\right)^{\frac{kappa+1}{kappa-1}},$$

$$\text{crit} == 2^{\frac{kappa}{kappa-1}} \left(\frac{1}{kappa + 1}\right)^{\frac{kappa}{kappa-1}},$$

$$\text{Bf} == 2^{\frac{kappa}{kappa-1}} \left(\frac{1}{kappa + 1}\right)^{\frac{kappa}{kappa-1}},$$

$$\text{cp} == cv + R$$
`};`

Expressions for enthalpy flows and mass flows.

In[351]:= `dE12 = qm12 cp (onNegative[qm12] T2 + onPositive[qm12] T1);`
`dE32 = qm32 cp (onNegative[qm32] T2 + onPositive[qm32] T3);`
`dE14 = qm14 cp (onNegative[qm14] T4 + onPositive[qm14] T1);`
`dE34 = qm34 cp (onNegative[qm34] T4 + onPositive[qm34] T3);`

`qm12 = (onPositive[p1 – p2] qm12Pos – onNegative[p1 – p2] qm12Neg);`
`qm32 = (onPositive[p3 – p2] qm32Pos – onNegative[p3 – p2] qm32Neg);`
`qm14 = (onPositive[p1 – p4] qm14Pos – onNegative[p1 – p4] qm14Neg);`
`qm34 = (onPositive[p3 – p4] qm34Pos – onNegative[p3 – p4] qm34Neg);`

The system equations to be solved in each time step

In[359]:= `systemEquationsDA = Simplify[{`

$$qm12Pos == Cf12\ p1\ p0\ \sqrt{\frac{T0}{T1}}\ Ng12,$$

$$qm12Neg == Cf12\ p2\ p0\ \sqrt{\frac{T0}{T2}}\ Ng12,$$

$$qm32Pos == Cf32\ p3\ p0\ \sqrt{\frac{T0}{T3}}\ Ng32,$$

$$qm32Neg == Cf32\ p2\ p0\ \sqrt{\frac{T0}{T2}}\ Ng32,$$

$$qm14Pos == Cf14\ p1\ p0\ \sqrt{\frac{T0}{T1}}\ Ng14,$$

$$qm14Neg == Cf14\ p4\ p0\ \sqrt{\frac{T0}{T4}}\ Ng14,$$

$$qm34Pos == Cf34\ p3\ p0\ \sqrt{\frac{T0}{T3}}\ Ng34,$$

$$qm34Neg == Cf34\ p4\ p0\ \sqrt{\frac{T0}{T4}}\ Ng34,$$

```
dE2 == dE12 + dE32,
dE4 == dE14 + dE34,
dE1 == -dE12 - dE14,
dE3 == -dE32 - dE34
   }];
```

Boundaries

The boundary equations for transmission line ports

In[360]:= `systemBoundaryEquations = {`
```
    p2 == (c2 + Zc2 dE2),
    p4 == (c4 + Zc4 dE4),
    p1 == (c1 + Zc1 dE1),
    p3 == (c3 + Zc3 dE3)
    };
```

Independent Variables

In[361]:= `systemVariables = {qm12Pos, qm12Neg, qm32Pos, qm32Neg,`
```
    qm14Pos, qm14Neg, qm34Pos, qm34Neg, dE2, dE4, dE1, dE3, p2, p4, p1, p3};
```

Expressions

Variables are calculated that are not directly involved in the system equations. The inlet flow is calculated as the outlet flow with reversed sign.

In[362]:= **expressions = {**
  qm1 == -qm12 - qm14,
  qm2 == qm12 + qm32,
  qm3 == -qm32 - qm34,
  qm4 == qm14 + qm34,
  Ng32e == Ng32,
  Ng12e == Ng12,
  Ng34e == Ng34,
  Ng14e == Ng14,
  Bfe == Bf
  };

In[363]:= **Compgen[file]**