Library of models of technological devices

Name:	TechApp
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Description:	Provides the library of models of technological devices.
Address:	DB in file: SQLite.LibDB.techApp (LibsDB.OscadaLibs.db)

Contents table

About the library

The library is created to provide the models of devices of technological processes. The library is not static, but based on the module JavaLikeCalc, allowing to create calculations on the Java-like language.

To address the functions of the library you should use the path: <DAQ.JavaLikeCalc.lib_techApp.*>. Where '*' function identifier in the library.

To connect the library of models of devices to the project of the OpenSCADA station it is possible by downloading the attached file of the database, placing it in in the database directory of the station's project and creating the database object for the DB module "SQLite", indicating the database file in the configuration.

For each function it was evaluated the execution time. Measurements were made on the system with the following parameters: Athlon 64 3000 + (2000MGts) + ALTLinux 5.1, 32bit by measuring the total execution time of the function when you call it 1000 times. Selection was made for the smallest value of the five computations. Time is in angle brackets and is measured in microseconds.

1 Conception

The basis of the model of each unit is the calculation of the input flow and output pressure based on the input pressure and output flow. In general, models of technological devices are described by difference equations for discrete machines.

Based on the functions of this library you can easily and quickly build models of technological processes in the module BlockCalc by combining the blocks in accordance with the technological scheme. Example of combination of several devices of the technological scheme is shown in Fig. 1.

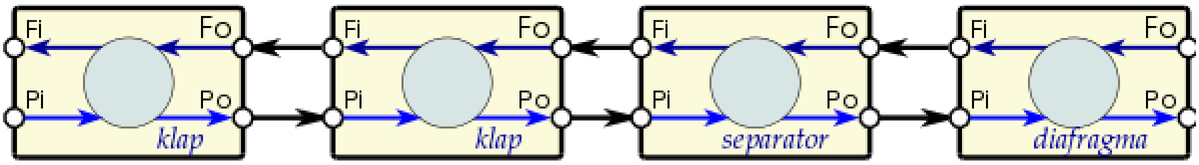

Fig. 1. An example of the block scheme of the technological process.

The basis of the model of any technological device are two basic formulas, namely the formula of flow and pressure. The canonical formula of the flow computation for the pipe section, or restriction of flow area is given by (1).

$$F = S * \sqrt{Qr * \Delta P} \quad (1)$$

Where:

F — mass flow (t/hour).
S — section (m2).
Qr — real density of the medium (kg/m3).
ΔP — pressure drop (at).

The actual density is calculated by the formula (2).

$$Qr = Q0 + Q0 * Kpr * (Pi - 1) \quad (2)$$

Where:

Q0 — density of the medium under normal conditions (kg/m3).
Kpr — coefficient of compressibility of the medium (0,001 — liquid; 0,95 — gas).
Pi — input pressure (at).

Each tube makes the dynamic resistance to the flow associated with the friction of the pipe walls and that depends on the flow velocity. The dynamic resistance of the pipe is expressed by (3). The total flow of the medium, taking into account the dynamic resistance is calculated by formula (4).

$$\Delta Pr = Kr * \frac{l}{D} \frac{Qr * v^2}{2} = Ktr * \frac{l * Qr}{2 * D} * \left(\frac{F}{Qr * S} \right)^2 = \frac{Ktr * l * F^2 * \sqrt{\pi}}{4 * S * Qr} \quad (3)$$

Where:

ΔP — pressure drop (at), the resistance of the pipe walls to flow of the medium.
Kr — coefficient of friction of the walls of the pipe.
D — diameter of the pipeline (m).
l — pipeline length (m).
v — flow velocity in the pipeline (m3/hour).

$$F = \frac{4 * S * Qr}{Ktr * lo * 1.7724 + 4 * Qr} * \sqrt{Qr * \Delta P} \quad (4)$$

Equation (1) describes the laminar outflow of medium to critical velocities. In the case of exceeding the critical flow velocity the calculation is made by the formula (5). A universal formula for calculating the flow at all speeds will have the formula (6).

$$F = S * \sqrt{Qr * (Pi - 0{,}528 * Pi)} \quad (5)$$

Where:

Pi — pressure at the beginning of the pipe.

$$F = \frac{4 * S * Qr}{Ktr * lo * 1.7724 + 4 * Qr} * \sqrt{Qr * (Pi - max(Po, Pi * 0{,}528))} \quad (6)$$

Where:

Po — pressure at the end of the pipe.

In dynamical systems the change of the flow at the end of the pipe does not change instantaneously, but lags behind the time travel of the medium plot from the beginning of the pipeline to its end. The time depends on the length of the pipe and velocity of the medium in the pipe. Delay of the flow changing at the end of the pipe can be described by formula (7). The resulting formula for calculating of the the flow in the pipe, taking into account the above features, written in the form (8).

$$Fo = F * (1 - e^{\frac{-t * v}{l}}) \quad (7)$$

Where:

Fo — flow at the end of the pipe.
t — time.
v — velocity of the flow = F/(Qr*S).

$$F = \frac{4 * S * Qr}{Ktr * lo * 1.7724 + 4 * Qr} * \sqrt{Qr * (Pi - max(Po, Pi * 0{,}528))} * (1 - e^{\frac{-t * F}{l * Qr * S}}) \quad (8)$$

The pressure of the medium in the volume is usually calculated identically for all cases by formula (9).

$$P = \int \Delta F \, dt = \int \frac{\Delta F}{(Q0 * Kpr * S * l)} dt \quad (9)$$

2 The library structure

The library contains about two dozen of models of the often needed technological processes devices and supporting elements. The functions' names and its parameters are available in three languages: English, Russian and Ukrainian.

Lag (lag) <1.2>

Description: Lag model. You can use this for sensors' variables lag imitation.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
out	Output	Real	Return	false	0
in	Input	Real	Input	false	0
t_lg	Lag time (s)	Real	Input	false	10
f_frq	Calc frequency (Hz)	Real	Input	true	100

Program:

```
out-=(out-in)/(t_lg*f_frq);
```

Noise (2 harmonic + rand) (noise) <3.5>

Description: Noise model. Contain three parts:

- first harmonic part;
- second harmonic part;
- noise based on randomize generator of numbers.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
out	Output	Real	Return	false	0
off	Main offset	Real	Input	false	1
a_g1	Harmonic part 1 amplitude	Real	Input	false	10
per_g1	Harmonic part 1 period (s)	Real	Input	false	10
a_g2	Harmonic part 2 amplitude	Real	Input	false	5
per_g2	Harmonic part 2 period (s)	Real	Input	false	0.1
a_rnd	Random numbers amplitude	Real	Input	false	1
f_frq	Calc function period (Hz)	Real	Input	true	100
tmp_g1	Harmonic part 1 counter	Real	Input	true	0
tmp_g2	Harmonic part 2 counter	Real	Input	true	0

Program:

```
tmp_g1=(tmp_g1>6.28)?0:tmp_g1+6.28/(per_g1*f_frq);
tmp_g2=(tmp_g2>6.28)?0:tmp_g2+6.28/(per_g2*f_frq);
out=off+a_g1*sin(tmp_g1)+a_g2*sin(tmp_g2)+a_rnd*(rand(2)-1);
```

Ball crane (ballCrane) <1.4>

Description: Ball crane model. Include going and estrangement time.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
pos	Position (%)	Real	Output	false	0
com	Command	Boolean	Input	false	0
st_open	State "Open"	Boolean	Output	false	0
st_close	State "Close"	Boolean	Output	false	1
t_full	Going time (s)	Real	Input	false	5
t_up	Estrangement time (s)	Real	Input	false	0.5
f_frq	Calc frequency (Hz)	Real	Input	true	100
tmp_up	Estrangement counter	Real	Input	true	0
lst_com	Last command	Boolean	Input	true	0

Program:

```
if( !(st_close && !com) && !(st_open && com) )
{
  tmp_up=(pos>0&&pos<100)?0:(tmp_up>0&&lst_com==com)?tmp_up-1./f_frq:t_up;
  pos+=(tmp_up>0)?0:(100.*(com?1.:-1.))/(t_full*f_frq);
  pos=(pos>100)?100:(pos<0)?0:pos;
  st_open=(pos>=100)?true:false;
  st_close=(pos<=0)?true:false;
  lst_com=com;
}
```

Separator (separator) <14>

Description: Separator model included two phase: liquid and gas.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (ata)	Real	Input	false	1
Si	Input cutset (m2)	Real	Input	false	0.2
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (ata)	Real	Output	false	1
So	Output cutset (m2)	Real	Input	false	0.2
lo	Output length (m)	Real	Input	false	10
Fo_ж	Output liquid flow (tones/h)	Real	Input	false	0
Po_ж	Output liquid pressure (ata)	Real	Output	false	1
Lж	Liquid level (%)	Real	Output	false	0
ProcЖ	% liquid.	Real	Input	false	0.01
Vap	Device capacity (m3)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Qж	Liquid density (kg/m3)	Real	Input	false	1000
f_frq	Calc frequency (Hz)	Real	Input	true	200

Program:

```
Fж=max(0,Fi*ProcЖ);
```

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,293,Si,Fo+Fж,Po,293,So,lo,Q0,0.95,0.
   01,f_frq);
Lж = max(0,min(100,Lж+0.27*(Fж-Fo_ж)/(Vap*Qж*f_frq)));
Po_ж = Po + Lж*Vap/Qж;
```

Valve (klap) <19.5>

Description: Valve model, include:

- two valve in one;
- super-critical speed;
- temperature change on baffling;
- work to one side, back valve;
- valve position speed control;
- nonlinear cut changing by open position.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (ata)	Real	Input	false	1
Ti	Input temperature (K)	Real	Input	false	273
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (ata)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	273
So	Output pipe cutset (m2)	Real	Input	false	.2
lo	Output pipe length (m)	Real	Input	false	10
S_kl1	Valve 1 cutset (m2)	Real	Input	false	.1
l_kl1	Valve 1 open (%)	Real	Input	false	0
t_kl1	Valve 1 open time (s)	Real	Input	false	10
S_kl2	Valve 2 cutset (m2)	Real	Input	false	.05
l_kl2	Valve 2 open (%)	Real	Input	false	0
t_kl2	Valve 2 open time (s)	Real	Input	false	5
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kln	Linearity coefficient	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
Ct	Warm capacity of environs	Real	Input	false	20
Riz	Warm resistance of isolation	Real	Input	false	20
noBack	Back valve	Boolean	Input	false	0
Fwind	Air speed	Real	Input	false	1
Twind	Air temperature	Real	Input	false	273
f_frq	Calc frequency (Hz)	Real	Input	true	200
tmp_l1	Position 1 lag	Real	Output	true	0
tmp_l2	Position 2 lag	Real	Output	true	0

Program:

```
Qr=Q0+Q0*Kpr*(Pi-1);
tmp_l1 += (abs(l_kl1-tmp_l1) > 5) ? 100*sign(l_kl1-tmp_l1)/(t_kl1*f_frq) :
   (l_kl1-tmp_l1)/(t_kl1*f_frq);
tmp_l2 += (abs(l_kl2-tmp_l2) > 5) ? 100*sign(l_kl2-tmp_l2)/(t_kl2*f_frq) :
   (l_kl2-tmp_l2)/(t_kl2*f_frq);
Sr=(S_kl1*pow(tmp_l1,Kln)+S_kl2*pow(tmp_l2,Kln))/pow(100,Kln);
```

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,Ti,Sr,EVAL_REAL,Po,293,So,lo,Q0,Kpr,
   0.01,f_frq);
if( noBack ) Fi = max(0,Fi);
Po = max(0,min(100,Po+0.27*(Fi-Fo)/(Q0*Kpr*So*lo*f_frq)));

To = max(0,min(2e3,To+(abs(Fi)*(Ti*pow(Po/Pi,0.02)-To)+(Fwind+1)*(Twind-
   To)/Riz)/(Ct*So*lo*Qr*f_frq)));
```

Lag (clear) (lagClean) <2.9>

Description: Model of clear lag (transportable). Provide for include some simple lag chains. Appointed for lags into long pipes.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
out	Output	Real	Return	false	0
in	Input	Real	Input	false	0
t_lg	Lag time (s)	Real	Input	false	10
f_frq	Calc frequency (Hz)	Real	Input	true	100
cl1	Chain 1	Real	Input	true	0
cl2	Chain 2	Real	Input	true	0
cl3	Chain 3	Real	Input	true	0

Program:

```
cl1-=(cl1-in)/(t_lg*f_frq/4);
cl2-=(cl2-cl1)/(t_lg*f_frq/4);
cl3-=(cl3-cl2)/(t_lg*f_frq/4);
out-=(out-cl3)/(t_lg*f_frq/4);
```

Boiler: barrel (boilerBarrel) <30.5>

Description: The model of the boiler's barrel.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi1	Input water flow (tones/h)	Real	Output	false	22
Pi1	Input water pressure (at)	Real	Input	false	43
Ti1	Input water temperature (K)	Real	Input	false	523
Si1	Input water cutset (m2)	Real	Input	false	0.6
Fi2	Input smoke gas flow (tones/h)	Real	Output	false	
Pi2	Input smoke gas pressure (at)	Real	Input	false	1.3
Ti2	Input smoke gas temperature (K)	Real	Input	false	1700
Si2	Input smoke gas cutset (m2)	Real	Input	false	10
Vi1	Barrel volume (m3)	Real	Input	false	3
Lo	Barrel level (%)	Real	Output	false	10
S	Heated surface (м2)	Real	Input	false	15
k	Heat transfer coefficient	Real	Input	false	0.8
Fo	Output steam flow (tones/h)	Real	Input	false	20
Po1	Output steam pressure (at)	Real	Output	false	41.68
To1	Output steam temperature (K)	Real	Output	false	10
So1	Output steam pipe cutset (m2)	Real	Input	false	0.5
lo1	Output steam pipe length (m)	Real	Input	false	5

Fo2	Output smoke gas flow (tones/h)	Real	Input	false	180
Po2	Output smoke gas pressure (at)	Real	Output	false	1
To2	Output smoke gas temperature (K)	Real	Input	false	0
Fpara	Inner barrel steam flow (tones/h)	Real	Output	false	0
Tv	Inner water temperature (K)	Real	Output	false	0
f_frq	Calc frequency (Hz)	Real	Input	false	200

Program:

```
// Water
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi1,Pi1,293,Si1,EVAL_REAL,Po1,293,So1,lo1,1
  e3,0.001,0.01,f_frq);
Fi1 = max(0,Fi1);

// Steam
Lo = max(0,min(100,Lo+(Fi1-Fpara)*100/(Vi1*1000*f_frq)));
To1 = (100*pow(Po1,0.241)+5)+273;

if( Tv<To1 )
{
  Tv+=(k*S*(Ti2-Tv)-Fi1*0.00418*(Tv-Ti1))/f_frq;
  Fpara=0;
}
if( Tv >= To1 )
{
  Tv=To1;
  Lambda=2750.0-0.00418*(Tv-273);
  Fpara=(5*S*Fi2*(Ti2-Tv)-Fi1*0.00418*(Tv-Ti1))/(Po1*Lambda);
}

To2=Ti2-Tv/k;
Po1 = max(0,min(100,Po1+0.27*(Fpara-Fo)/(1.2*0.98*((1-
  Lo/100)*Vi1+So1*lo1)*f_frq)));

// Smoke gas
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi2,Pi2,293,Si2,Fo2,Po2,293,Si2,30,1.2,0.98
  ,0.01,f_frq);
```

Boiler: burner (boilerBurner) <50.5>

Description: The fire chamber's of the boiler model which works with three fuels: blast-furnace gas, coke and natural gas.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi1	Input blast furnace gas flow (tone/h)	Real	Output	false	
Pi1	Input blast furnace gas pressure (at)	Real	Input	false	
Ti1	Input blast furnace gas temperature (K)	Real	Input	false	40
Si1	Input blast furnace gas pipe cutset (m2)	Real	Input	false	
Fi2	Input natural gas flow (tone/h)	Real	Output	false	
Pi2	Input natural gas pressure (at)	Real	Input	false	
Ti2	Input natural gas temperature (K)	Real	Input	false	20
Si2	Input natural gas pipe cutset (m2)	Real	Input	false	
Fi3	Input coke oven gas flow (tone/h)	Real	Output	false	
Pi3	Input coke oven gas pressure (at)	Real	Input	false	
Ti3	Input coke oven gas temperature (K)	Real	Input	false	0

Si3	Input coke oven gas pipe cutset (m2)	Real	Input	false	
Fi4	Input air flow (tone/h)	Real	Output	false	
Pi4	Input air pressure (at)	Real	Input	false	
Ti4	Input air temperature (K)	Real	Input	false	20
Si4	Input air cutset (m2)	Real	Input	false	
Fo	Output smoke gas flow (tones/h)	Real	Input	false	
Po	Output smoke gas pressure (at)	Real	Output	false	
To	Output smoke gas temperature (K)	Real	Output	false	
So	Output smoke gas pipe cutset (m2)	Real	Input	false	90
lo	Output smoke gas pipe length (m)	Real	Input	false	
V	Burner volume (m3)	Real	Input	false	830
CO	The percentage of CO in the flue stack gases (%)	Real	Output	false	
O2	The percentage of O2 in the flue stack gases (%)	Real	Output	false	
f_frq	Calc frequency (Hz)	Real	Input	false	200

Program:

```
using DAQ.JavaLikeCalc.lib_techApp;
pipeBase(Fi1,Pi1,Ti1,Si1,EVAL_REAL,Po,293,So,lo,1.2,0.95,0.01,f_frq);
Fi1 = max(0,Fi1);
pipeBase(Fi2,Pi2,Ti2,Si2,EVAL_REAL,Po,293,So,lo,0.7,0.95,0.01,f_frq);
Fi2 = max(0,Fi2);
pipeBase(Fi3,Pi3,Ti3,Si3,EVAL_REAL,Po,293,So,lo,1.33,0.95,0.01,f_frq);
Fi3 = max(0,Fi3);
pipeBase(Fi4,Pi4,Ti4,Si4,EVAL_REAL,Po,293,So,lo,1.293,0.95,0.01,f_frq);
Fi4 = max(0,Fi4);

Neobhod_vzd = Fi1+10*Fi2+4*Fi3;
F_DG = Fi1+Fi2+Fi3+Fi4;
O2 = max(0,min(100,(Fi4-Neobhod_vzd)*100/F_DG));
CO = min(100, (O2<1) ? (1.2*abs(O2)) : 0);
koef = min(1,Fi4/Neobhod_vzd);
Q = koef*(8050*Fi2+3900*Fi3+930*Fi1);
delta_t = Q/(F_DG*1.047);
To = max(0,min(2000,(delta_t+(Ti4-273)+(Ti3-273)*(Fi3/Fi1)+(Ti2-273)*(Fi2/Fi1)+
   (Ti1-273)*(Fi1/Fi4))+273));

Po = max(0,min(10,Po+0.27*(F_DG-Fo)/(1.2*0.95*(So*lo+V)*f_frq)));
```

Network (loading) (net) <13>

Description: Loading with constant pressure on network. Contain parameter for noise connection.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	10
Pi	Input pressure (ata)	Real	Input	false	1
Po	Output pressure setpoint (ata)	Real	Input	false	1
So	Output pipe cutset (m2)	Real	Input	false	0.1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
Noise	Input flow's noise	Real	Input	false	1
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
f_frq	Calc frequency (Hz)	Real	Input	true	200

Program:
```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,293,So,EVAL_REAL,Po,293,So,10,Q0,Kpr
  ,0.01,f_frq);
```

Source (pressure) (src_press) <12>

Description: Source pressure with constant pressure. Contained the parameter for noise connection.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Pi	Input pressure setpoint (at)	Real	Input	false	10
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
So	Output pipe cutset (m2)	Real	Input	false	0.1
lo	Output pipe length (m)	Real	Input	false	100
Noise	Input flow's noise	Real	Input	false	1
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	200
Fit	Input flow laged	Real	Output	true	0

Program:
```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fit,Pi*Noise,293,So,Fo,Po,293,So,lo,Q0,Kpr
  ,0.01,f_frq);
```

Air cooler (cooler) <16.5>

Description: Model of the air cooler for gas flow.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Ti	Input temperature (K)	Real	Input	false	273
Si	Cooler's pipes cutset (m2)	Real	Input	false	0.05
li	Full cooler's pipes length (m)	Real	Input	false	10
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	273
So	Output pipe cutset (m2)	Real	Input	false	.2
lo	Output pipe length (m)	Real	Input	false	10
Tair	Cooling air temperature (K)	Real	Input	false	283
Wc	Cooler performance	Real	Input	false	200
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Ct	Warm capacity of environs	Real	Input	false	100
Rt	Warm resistance of isolation	Real	Input	false	1
f_frq	Calc frequency (Hz)	Real	Input	true	200

Program:
```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,293,Si,Fo,Po,293,So,lo,Q0,0.95,0.01,
  f_frq);
```

```
Qr = Q0+Q0*0.95*(Pi-1);
To+=(Fi*(Ti-To)+Wc*(Tair-To)/Rt)/(Ct*(Si*li+So*lo)*Qr*f_frq);
```

Gas compressor (compressor) <12>

Description: Model of the gas compressor. Implement surge effect. Sarge count from the dynamic-gas curve, and next count coefficient of sarge margin.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Ti	Input temperature (K)	Real	Input	false	273
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	273
So	Output pipe cutset (m2)	Real	Input	false	0.2
lo	Output pipe length (m)	Real	Input	false	2
Kzp	Surge protect margin coefficient	Real	Output	false	0.1
N	Turnovers (1000 x turn/min)	Real	Input	false	0
V	Capacity (m3)	Real	Input	false	7
Kpmp	Surge coefficient (surge point)	Real	Input	false	0.066
Kslp	Slope coefficient of surge curve	Real	Input	false	0.08
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
Ct	Warm capacity of environs	Real	Input	false	100
Riz	Warm resistance of isolation	Real	Input	false	100
Fwind	Air speed	Real	Input	false	1
Twind	Air temperature	Real	Input	false	273
f_frq	Calc frequency (Hz)	Real	Input	true	200
Fit	Input flow laged	Real	Output	true	0

Program:

```
Pmax = max(Pi,Po);
Pmin = min(Pi,Po);
Qr = Q0+Q0*Kpr*(Pi-1);
Qrf = Q0+Q0*Kpr*(Pmax-1);
Ftmp=(N>0.1)?(1-10*(Po-Pi)/(Qr*(pow(N,3)+0.1)*Kpmp)):1;
Kzp=1-Ftmp;  //Коэффиц. запаса
Fi=V*N*Qr*sign(Ftmp)*pow(abs(Ftmp),Kslp)+
     0.3*(4*So*Qrf/(0.01*lo*1.7724+4*Qrf))*sign(Pi-Po)*pow(Qrf*(Pmax-
  max(Pmax*0.528,Pmin)),0.5);
Fit -= (Fit-Fi)/max(1,(lo*f_frq)/max(1e-4,abs(Fi/(Qrf*So))));
Po = max(0,min(100,Po+0.27*(Fi-Fo)/(Q0*Kpr*So*lo*f_frq)));

To+=(abs(Fi)*(Ti*pow(Po/Pi,0.3)-To)+(Fwind+1)*(Twind-To)/Riz)/
  (Ct*(V+So*lo)*Qr*f_frq);
```

Source (flow) (src_flow) <2.2>

Description: Source of constant flow. Contained parameter for noise connection.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow setpoint (tones/h)	Real	Input	false	10
Fo	Output flow (tones/h)	Real	Input	false	10
Po	Output pressure (at)	Real	Output	false	1
So	Output pipe cutset (m2)	Real	Input	false	0.1
lo	Output pipe length (m)	Real	Input	false	100
Noise	Input flow's noise	Real	Input	false	1
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	100

Program:

```
Po = max(0,min(100,Po+0.27*(Noise*Fi-Fo)/(Q0*Kpr*So*lo*f_frq)));
```

Pipe-base (pipeBase) <11.5>

Description: Implementation of the basic foundations of the model pipe:

- Flow in the pipe, taking into account the speed, pressure drop, resistance due to friction and the critical flow.
- Calculation of pressure.
- Accounting for medium density and degree of compressibility for both gases and liquids.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Ti	Input temperature (K)	Real	Input	false	293
Si	Input cutset (m2)	Real	Input	false	.2
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	293
So	Output cutset (m2)	Real	Input	false	.2
lo	Output length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.98
Ktr	Coefficient of friction	Real	Input	false	0.01
f_frq	Calc frequency (Hz)	Real	Input	false	100

Program:

```
Pmax = max(Pi,Po);
Pmin = min(Pi,Po);
Qr = Q0+Q0*Kpr*(Pmax-1);
Fit = 630*(4*Si*So*Qr/(Ktr*lo*1.7724*Si+4*So*Qr))*sign(Pi-Po)*pow(Qr*(Pmax-
   max(Pmax*0.528,Pmin)),0.5);
Fi -= (Fi-Fit)/max(1,(lo*f_frq)/max(1,abs(Fit/(Qr*So))));
if( !Fo.isEVal() ) Po = max(0,min(100,Po+0.27*(Fi-Fo)/(Q0*Kpr*So*lo*f_frq)));
```

Pipe 1->1 (pipe1_1) <36.5>

Description: Model of the pipe by scheme: 1 -> 1.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
So	Output cutset (m2)	Real	Input	false	.2
lo	Output length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	200
Pti	Pti	Real	Output	true	1
Fto	Fto	Real	Output	true	0
Pt1	Pt1	Real	Output	true	1
Ft1	Ft1	Real	Output	true	0

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,293,So,Ft1,Pti,293,So,0.33*lo,Q0,Kpr,
   0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Ft1,Pti,293,So,Fto,Pt1,293,So,0.33*lo,Q0,Kp
   r,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fto,Pt1,293,So,Fo,Po,293,So,0.33*lo,Q0,Kpr,
   0.01,f_frq);
```

Pipe 2->1 (pipe2_1) <26>

Description: Model of the pipe by scheme: 2 -> 1.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi1	Input 1 flow (tones/h)	Real	Output	false	0
Pi1	Input 1 pressure (at)	Real	Input	false	1
Ti1	Input 1 temperature (K)	Real	Input	false	273
Si1	Input 1 cutset (m2)	Real	Input	false	0.2
Fi2	Input 2 flow (tones/h)	Real	Output	false	0
Pi2	Input 2 pressure (at)	Real	Input	false	1
Ti2	Input 2 temperature (K)	Real	Input	false	273
Si2	Input 2 cutset (m2)	Real	Input	false	0.2
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	273
So	Output cutset (m2)	Real	Input	false	.2
lo	Output length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
Ct	Warm capacity of environs	Real	Input	false	20
Riz	Warm resistance of isolation	Real	Input	false	20

ID	Parameter	Type	Mode	Hide	Default
Fwind	Air speed	Real	Input	false	1
Twind	Air temperature (K)	Real	Input	false	273
f_frq	Calc frequency (Hz)	Real	Input	true	100

Program:
```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi1,Pi1,293,Si1,EVAL_REAL,Po,293,So,lo,Q0,K
  pr,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi2,Pi2,293,Si2,EVAL_REAL,Po,293,So,lo,Q0,K
  pr,0.01,f_frq);
Po = max(0,min(100,Po+0.27*(Fi1+Fi2-Fo)/(Q0*Kpr*So*lo*f_frq)));
To = max(0,To+(Fi1*(Ti1-To)+Fi2*(Ti2-To)+(Fwind+1)*(Twind-To)/Riz)/
  (Ct*So*lo*Q0*f_frq));
```

Pipe 3->1 (pipe3_1) <36>

Description: Model of the pipe by scheme: 3 -> 1.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi1	Input 1 flow (tones/h)	Real	Output	false	0
Pi1	Input 1 pressure (at)	Real	Input	false	1
Ti1	Input 1 temperature (K)	Real	Input	false	273
Si1	Input 1 cutset (m2)	Real	Input	false	0.2
Fi2	Input 2 flow (tones/h)	Real	Output	false	0
Pi2	Input 2 pressure (at)	Real	Input	false	1
Ti2	Input 2 temperature (K)	Real	Input	false	273
Si2	Input 2 cutset (m2)	Real	Input	false	0.2
Fi3	Input 3 flow (tones/h)	Real	Output	false	0
Pi3	Input 3 pressure (at)	Real	Input	false	1
Ti3	Input 3 temperature (K)	Real	Input	false	273
Si3	Input 3 cutset (m2)	Real	Input	false	0.2
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
To	Output temperature (K)	Real	Output	false	273
So	Output cutset (m2)	Real	Input	false	.2
lo	Output length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
Ct	Warm capacity of environs	Real	Input	false	20
Riz	Warm resistance of isolation	Real	Input	false	20
Fwind	Air speed	Real	Input	false	1
Twind	Air temperature (K)	Real	Input	false	273
f_frq	Calc frequency (Hz)	Real	Input	true	100

Program:
```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi1,Pi1,293,Si1,EVAL_REAL,Po,293,So,lo,Q0,K
  pr,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi2,Pi2,293,Si2,EVAL_REAL,Po,293,So,lo,Q0,K
  pr,0.01,f_frq);
```

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi3,Pi3,293,Si3,EVAL_REAL,Po,293,So,lo,Q0,K
   pr,0.01,f_frq);
Po = max(0,min(100,Po+0.27*(Fi1+Fi2+Fi3-Fo)/(Q0*Kpr*So*lo*f_frq)));
To = max(0,To+(Fi1*(Ti1-To)+Fi2*(Ti2-To)+Fi3*(Ti3-To)+(Fwind+1)*(Twind-To)/Riz)/
   (Ct*So*lo*Q0*f_frq));
```

Pipe 1->2 (pipe1_2) <25.5>

Description: Model of the pipe by scheme: 1 -> 2.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Fo1	Output 1 flow (tones/h)	Real	Input	false	0
Po1	Output 1 pressure (at)	Real	Output	false	1
So1	Output 1 cutset (m2)	Real	Input	false	.2
lo1	Output 1 length (m)	Real	Input	false	10
Fo2	Output 2 flow (tones/h)	Real	Input	false	0
Po2	Output 2 pressure (at)	Real	Output	false	1
So2	Output 2 cutset (m2)	Real	Input	false	.2
lo2	Output 2 length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	100
F1tmp	Temporary flow 1	Real	Output	true	0
F2tmp	Temporary flow 2	Real	Output	true	0
Pot1	Temporary pressure 1	Real	Output	true	1
Pot2	Temporary pressure 2	Real	Output	true	1

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F1tmp,Pi,293,So1,Fo1,Po1,293,So1,lo1,Q0,Kpr
   ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F2tmp,Pi,293,So2,Fo2,Po2,293,So2,lo2,Q0,Kpr
   ,0.01,f_frq);
Fi=F1tmp+F2tmp;
```

Pipe 1->3 (pipe1_3) <36.5>

Description: Model of the pipe by scheme: 1 -> 3.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Fo1	Output 1 flow (tones/h)	Real	Input	false	0
Po1	Output 1 pressure (at)	Real	Output	false	1
So1	Output 1 cutset (m2)	Real	Input	false	.2
lo1	Output 1 length (m)	Real	Input	false	10
Fo2	Output 2 flow (tones/h)	Real	Input	false	0
Po2	Output 2 pressure (at)	Real	Output	false	1

ID	Parameter	Type	Mode	Hide	Default
So2	Output 2 cutset (m2)	Real	Input	false	.2
lo2	Output 2 length (m)	Real	Input	false	10
Fo3	Output 3 flow (tones/h)	Real	Input	false	0
Po3	Output 3 pressure (at)	Real	Output	false	1
So3	Output 3 cutset (m2)	Real	Input	false	.2
lo3	Output 3 length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	100
F1tmp	Temporary flow 1	Real	Output	true	0
F2tmp	Temporary flow 2	Real	Output	true	0
F3tmp	Temporary flow 3	Real	Output	true	0
Pot1	Temporary pressure 1	Real	Output	true	1
Pot2	Temporary pressure 2	Real	Output	true	1
Pot3	Temporary pressure 3	Real	Output	true	1

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F1tmp,Pi,293,So1,Fo1,Po1,293,So1,lo1,Q0,Kpr
   ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F2tmp,Pi,293,So2,Fo2,Po2,293,So2,lo2,Q0,Kpr
   ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F3tmp,Pi,293,So3,Fo3,Po3,293,So3,lo3,Q0,Kpr
   ,0.01,f_frq);
Fi=F1tmp+F2tmp+F3tmp;
```

Pipe 1->4 (pipe1_4) <47.5>

Description: Model of the pipe by scheme: 1 -> 4.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Fo1	Output 1 flow (tones/h)	Real	Input	false	0
Po1	Output 1 pressure (at)	Real	Output	false	1
So1	Output 1 cutset (m2)	Real	Input	false	.2
lo1	Output 1 length (m)	Real	Input	false	10
Fo2	Output 2 flow (tones/h)	Real	Input	false	0
Po2	Output 2 pressure (at)	Real	Output	false	1
So2	Output 2 cutset (m2)	Real	Input	false	.2
lo2	Output 2 length (m)	Real	Input	false	10
Fo3	Output 3 flow (tones/h)	Real	Input	false	0
Po3	Output 3 pressure (at)	Real	Output	false	1
So3	Output 3 cutset (m2)	Real	Input	false	.2
lo3	Output 3 length (m)	Real	Input	false	10
Fo4	Output 4 flow (tones/h)	Real	Input	false	0
Po4	Output 4 pressure (at)	Real	Output	false	1
So4	Output 4 cutset (m2)	Real	Input	false	.2

ID	Parameter	Type	Mode	Hide	Default
lo4	Output 4 length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	100
F1tmp	Temporary flow 1	Real	Output	true	0
F2tmp	Temporary flow 2	Real	Output	true	0
F3tmp	Temporary flow 3	Real	Output	true	0
F4tmp	Temporary flow 4	Real	Output	true	0
Pot1	Temporary pressure 1	Real	Output	true	1
Pot2	Temporary pressure 2	Real	Output	true	1
Pot3	Temporary pressure 3	Real	Output	true	1
Pot4	Temporary pressure 4	Real	Output	true	1

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F1tmp,Pi,293,So1,Fo1,Po1,293,So1,lo1,Q0,Kpr
  ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F2tmp,Pi,293,So2,Fo2,Po2,293,So2,lo2,Q0,Kpr
  ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F3tmp,Pi,293,So3,Fo3,Po3,293,So3,lo3,Q0,Kpr
  ,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(F4tmp,Pi,293,So4,Fo4,Po4,293,So4,lo4,Q0,Kpr
  ,0.01,f_frq);
Fi=F1tmp+F2tmp+F3tmp+F4tmp;
```

Valve proc. mechanism (klapMech) <3>

Description: Model of the valve process mechanism. Include going time (aperiodic chain of two level) and estrangement time.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
pos	Position (%)	Real	Output	false	0
pos_sensor	Position by sensor (%)	Real	Output	false	0
com	Command	Real	Input	false	0
st_open	State "Open"	Boolean	Output	false	0
st_close	State "Close"	Boolean	Output	false	1
t_full	Going time (s)	Real	Input	false	3
t_up	Estrangement time (s)	Real	Input	false	1
t_sensor	Sensors' lag time (s)	Real	Input	false	1
f_frq	Calc frequency (Hz)	Real	Input	true	100
tmp_up	Estrangement count	Real	Output	false	0
lst_com	Last command	Real	Output	false	0

Program:

```
if( (pos >= 99 && com >= 99) || (pos <= 1 && com <=1 ) )
{
  tmp_up = t_up;
  if(pos>=99) { pos=100; st_open=true; }
  else { pos = 0; st_close=true; }
}
else if( tmp_up > 0 ) tmp_up-=1./f_frq;
```

```
else
{
  st_open=st_close=false;
  lst_com+=(com-lst_com)/(0.5*t_full*f_frq);
  pos+=(lst_com-pos)/(0.5*t_full*f_frq);
}
pos_sensor+=(pos-pos_sensor)/(t_sensor*f_frq);
```

Diaphragm (diafragma) <14>

Description: Diaphragm model.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi	Input flow (tones/h)	Real	Output	false	0
Pi	Input pressure (at)	Real	Input	false	1
Fo	Output flow (tones/h)	Real	Input	false	0
Po	Output pressure (at)	Real	Output	false	1
dP	Pressure differential (kPa)	Real	Output	false	0
Sdf	Diaphragm cutset (m2)	Real	Input	false	0.1
So	Output pipe cutset (m2)	Real	Input	false	0.2
lo	Output pipe length (m)	Real	Input	false	10
Q0	Norm density of environs (kg/m3)	Real	Input	false	1
Kpr	Compressibility coefficient (0...1)	Real	Input	false	0.95
f_frq	Calc frequency (Hz)	Real	Input	true	100

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi,Pi,293,Sdf,Fo,Po,293,So,lo,Q0,Kpr,0.01,
   f_frq);
dP -= (dP-100*(Pi-Po))/f_frq;
```

Heat exchanger (heatExch) <28.4>

Description: The model of the heat exchanger, it calculates the heat exchange of the two streams.

Parameters:

ID	Parameter	Type	Mode	Hide	Default
Fi1	Input 1 flow (tones/h)	Real	Input	false	20
Pi1	Input 1 pressure (at)	Real	Input	false	1
Ti1	Input 1 temperature (K)	Real	Input	false	20
Si1	Input 1 cutset (m2)	Real	Input	false	1
li1	Input 1 length (m)	Real	Input	false	10
Q0i1	Input 1 norm density (kg/m3)	Real	Input	false	1
Kpr1	Input 1 compressibility coefficient (0...1)	Real	Input	false	0.9
Ci1	Input 1 warm capacity	Real	Input	false	1
Fi2	Input 2 flow (tones/h)	Real	Input	false	20
Pi2	Input 2 pressure (at)	Real	Input	false	1
Ti2	Input 2 temperature (K)	Real	Input	false	40
Si2	Input 2 cutset (m2)	Real	Input	false	1
li2	Input 2 length (m)	Real	Input	false	10
Q0i2	Input 2 norm density (kg/m3)	Real	Input	false	1
Kpr2	Input 2 compressibility coefficient (0...1)	Real	Input	false	0.9

ID	Parameter	Type	Mode	Hide	Default
Ci2	Input 2 warm capacity	Real	Input	false	1
ki	Heat transfer coefficient	Real	Input	false	0.9
Fo1	Output 1 flow (tones/h)	Real	Input	false	0
Po1	Output 1 pressure (at)	Real	Output	false	1
To1	Output 1 temperature (K)	Real	Output	false	273
So1	Output 1 cutset (m2)	Real	Output	false	1
lo1	Output 1 length (m)	Real	Output	false	10
Fo2	Output 2 flow (tones/h)	Real	Input	false	0
Po2	Output 2 pressure (at)	Real	Output	false	1
To2	Output 2 temperature (K)	Real	Output	false	273
So2	Output 2 cutset (m2)	Real	Output	false	1
lo2	Output 2 length (m)	Real	Output	false	10
f_frq	Calc frequency (Hz)	Real	Input	false	200

Program:

```
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi1,Pi1,Ti1,Si1,Fo1,Po1,293,So1,lo1,Q0i1,K
  pr1,0.01,f_frq);
DAQ.JavaLikeCalc.lib_techApp.pipeBase(Fi2,Pi2,Ti2,Si2,Fo2,Po2,293,So2,lo2,Q0i2,K
  pr2,0.01,f_frq);

To1=max(0,min(1e4,(Fi1*Ti1*Ci1+ki*Fi2*Ti2*Ci2)/(Fi1*Ci1+ki*Fi2*Ci2)));
To2=max(0,min(1e4,(ki*Fi1*Ti1*Ci1+Fi2*Ti2*Ci2)/(ki*Fi1*Ci1+Fi2*Ci2)));
```