⌄ BPL_TEST2_PID_Fedbatch_reg6 script with FMPy

The key library FMPy is installed.

After the installation a small application BPL_TEST2_PID_Fedbatch_reg6 is loaded and run. You can continue with this example if you like.

```
!lsb_release -a # Actual VM Ubuntu version used by Google
```

```
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 22.04.4 LTS
Release:        22.04
Codename:       jammy
```

```
!python --version
```

```
Python 3.11.11
```

```
!pip install fmpy
```

```
Collecting fmpy
  Downloading FMPy-0.3.22-py3-none-any.whl.metadata (1.9 kB)
Requirement already satisfied: attrs in /usr/local/lib/python3.11/dist-package
Requirement already satisfied: Jinja2 in /usr/local/lib/python3.11/dist-packag
Collecting lark (from fmpy)
  Downloading lark-1.2.2-py3-none-any.whl.metadata (1.8 kB)
Requirement already satisfied: lxml in /usr/local/lib/python3.11/dist-packages
Requirement already satisfied: msgpack in /usr/local/lib/python3.11/dist-packa
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-package
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.11/d:
Downloading FMPy-0.3.22-py3-none-any.whl (4.9 MB)
  ──────────────────────────────────────── 4.9/4.9 MB 33.4 MB/s eta 0:00:00
Downloading lark-1.2.2-py3-none-any.whl (111 kB)
  ──────────────────────────────────────── 111.0/111.0 kB 3.2 MB/s eta 0:00:(
Installing collected packages: lark, fmpy
Successfully installed fmpy-0.3.22 lark-1.2.2
```

⌄ BPL_TEST2_Fedbatch setup

Now specific installation and the run simulations. Start with connecting to Github. Then upload the two files:

- FMU - BPL_TEST2_Fedbatch_linux_om_me.fmu
- Setup-file - BPL_TEST2_Fedbatch_fmpy_explore.py

```
%%bash
git clone https://github.com/janpeter19/CONF_2023_10_MODELICA15
```

⇥   Cloning into 'CONF_2023_10_MODELICA15'...

```
%cd CONF_2023_10_MODELICA15
```

⇥   /content/CONF_2023_10_MODELICA15

```
run -i BPL_TEST2_PID_Fedbatch_reg6_fmpy_explore.py
```

⇥   Linux - run FMU pre-comiled OpenModelica 1.21.0

    Model for bioreactor has been setup. Key commands:
     - par()   - change of parameters and initial values
     - init()   - change initial values only
     - simu()   - simulate and plot
     - newplot()   - make a new plot
     - show()   - show plot from previous simulation
     - disp()   - display parameters and initial values from the last simulatio
     - describe() - describe culture, broth, parameters, variables with values/ur

    Note that both disp() and describe() takes values from the last simulation
    and the command process_diagram() brings up the main configuration

    Brief information about a command by help(), eg help(simu)
    Key system information is listed with the command system_info()
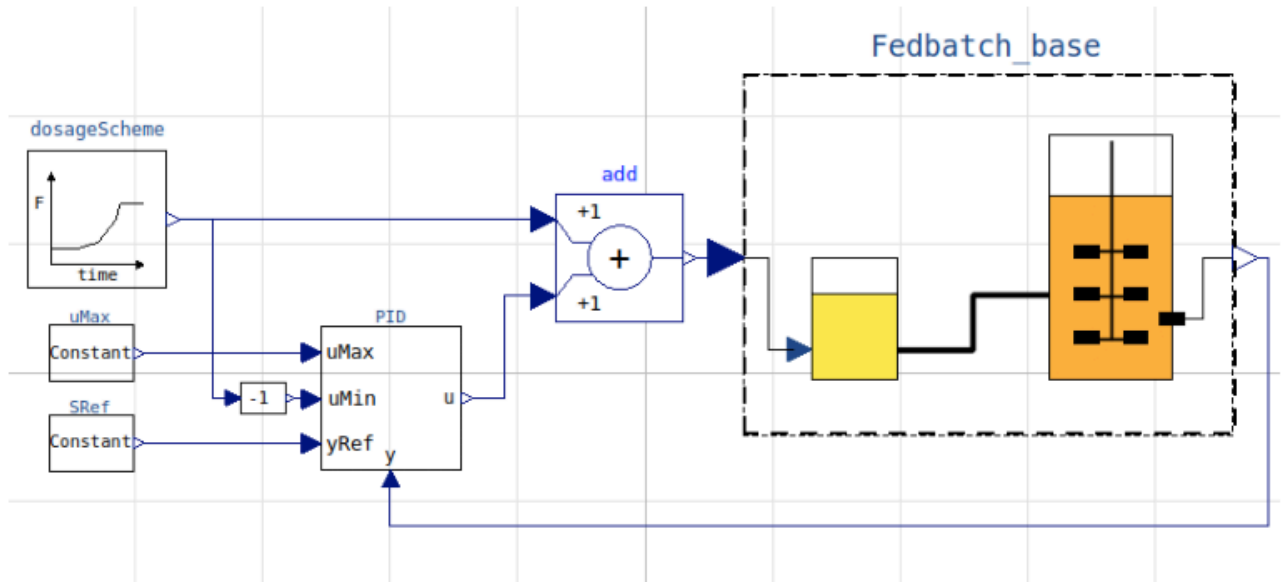
```
%matplotlib inline
plt.rcParams['figure.figsize'] = [25/2.54, 20/2.54]
```

```
import warnings
warnings.filterwarnings("ignore")
```

∨ BPL_TEST2_Fedbatch - demo

```
process_diagram()
```

```
describe('culture'); print(); #describe('liquidphase')
```

Simplified text book mode — only substrate S and cell concentration X

```
par(Y=0.40, qSmax=1.0, Ks=0.1)
init(V_0=1e3, VX_0=1e3, VS_0=10*1e3)
# Culture parameters
# Process initialization
par(S_in=600)
par(t_start=4.3, F_start=4, mu_feed=0.2, F_max=35)
par(S_ref=0.1) # Substrate controller
par(t_regStart=4.3)
par(uMax=50)

newplot()
ax2.set_ylim([0, 0.45]); ax3.set_ylim([0, 1])
setLines(['-']);
par(K=30, Ti=0.5)
simu(8)
```

Fedbatch cultivation with substrate control
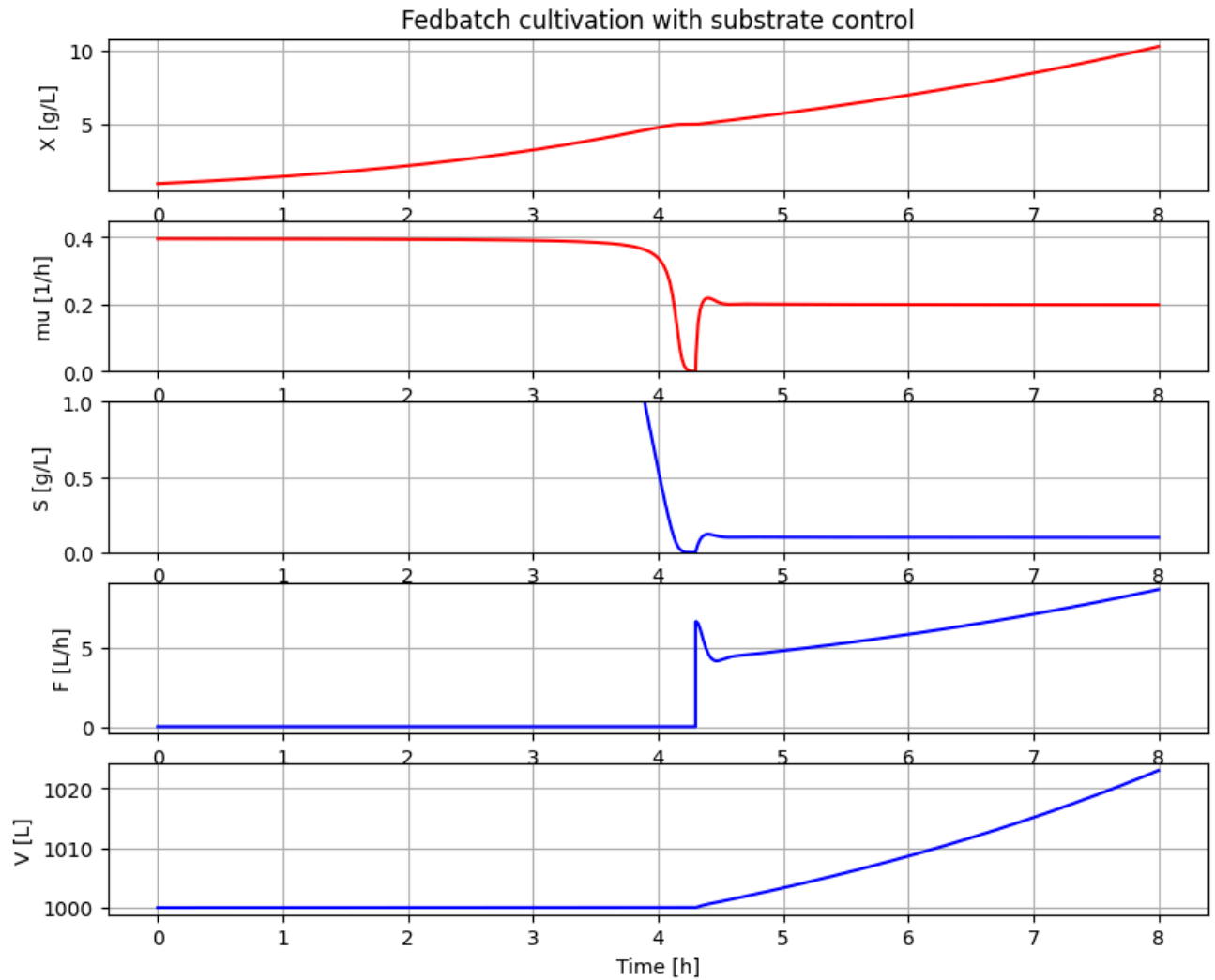
```
disp(mode='long')
```

```
bioreactor.V_0 : V_0 : 1000.0
bioreactor.m_0[1] : VX_0 : 1000.0
bioreactor.m_0[2] : VS_0 : 10000.0
bioreactor.culture.Y : Y : 0.4
bioreactor.culture.qSmax : qSmax : 1.0
bioreactor.culture.Ks : Ks : 0.1
feedtank.V_0 : feedtank_V_0 : 10.0
feedtank.c_in[2] : S_in : 600
dosagescheme.mu_feed : mu_feed : 0.2
dosagescheme.F_0 : F_0 : 0.0
dosagescheme.t_start : t_start : 4.3
dosagescheme.F_start : F_start : 4
dosagescheme.F_max : F_max : 35
substrateSensor.x_0 : Sensor_x_0 : 0
substrateRef.k : S_ref : 0.1
t_regStart : t_regStart : 4.3
```

```
        PIDreg.K : K : 30
        PIDreg.Ti : Ti : 0.5
        PIDreg.I_0 : I_0 : 0
        uMax : uMax : 50
```

```
describe('mu')
```

Cell specific growth rate variable : 0.199 [1/h]

```
describe('parts')
```

['bioreactor', 'bioreactor.culture', 'dosagescheme', 'feedtank', 'PIDreg', 'su

```
describe('MSL')
```

MSL: 3.2.3 – used components: RealInput, RealOutput

```
system_info()
```

```
    System information
     -OS: Linux
     -Python: 3.11.11
     -Scipy: not installed in the notebook
     -FMPy: 0.3.22
     -FMU by: OpenModelica Compiler OpenModelica 1.21.0
     -FMI: 2.0
     -Type: ME
     -Name: BPL_TEST2_PID.Fedbatch_reg6
     -Generated: 2023-08-22T10:54:51Z
      MCL  2 2 2
```