▾ BPL_TEST2_PID_Fedbatch_reg6 script with FMPy 0.3.15

The key library FMPy ver 0.3.15 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 22.04.2 LTS
    Release:        22.04
    Codename:       jammy
```

```
%env PYTHONPATH=

    env: PYTHONPATH=
```

```
!wget https://repo.anaconda.com/miniconda/Miniconda3-py310_23.1.0-1-Linux-x86_64.sh
!chmod +x Miniconda3-py310_23.1.0-1-Linux-x86_64.sh
!bash ./Miniconda3-py310_23.1.0-1-Linux-x86_64.sh -b -f -p /usr/local
import sys
sys.path.append('/usr/local/lib/python3.10/site-packages/')

    --2023-09-13 18:32:00--  https://repo.anaconda.com/miniconda/Miniconda3-py310_23.1.0-1-Linux-x86_64.s
    Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.131.3, 104.16.130.3, 2606:4700::6810:8203,
    Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.131.3|:443... connected.
    HTTP request sent, awaiting response... 200 OK
    Length: 74403966 (71M) [application/x-sh]
    Saving to: 'Miniconda3-py310_23.1.0-1-Linux-x86_64.sh'

    Miniconda3-py310_23 100%[===================>]  70.96M   242MB/s    in 0.3s

    2023-09-13 18:32:00 (242 MB/s) - 'Miniconda3-py310_23.1.0-1-Linux-x86_64.sh' saved [74403966/74403966

    PREFIX=/usr/local
    Unpacking payload ...

    Installing base environment...


    Downloading and Extracting Packages


    Downloading and Extracting Packages

    Preparing transaction: done
    Executing transaction: done
    installation finished.
```

```
!conda update -n base -c defaults conda --yes
```

```
Preparing transaction: done
Verifying transaction: done
Executing transaction: done
```

```
!conda --version
!python --version
```

```
conda 23.7.4
Python 3.10.13
```

```
!conda install -c conda-forge fmpy --yes # Install the key package
```

```
       Preparing transaction: done
       Verifying transaction: done
       Executing transaction: done
```

```
!conda install matplotlib --yes
```

```
    Preparing transaction: done
    Verifying transaction: done
    Executing transaction: done
```

```
#!conda install scipy --yes
```

```
#!conda install xlrd --yes
```

```
#!conda install openpyxl --yes
```

▾ 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 simulation
     - describe()  - describe culture, broth, parameters, variables with values/units

    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()
```
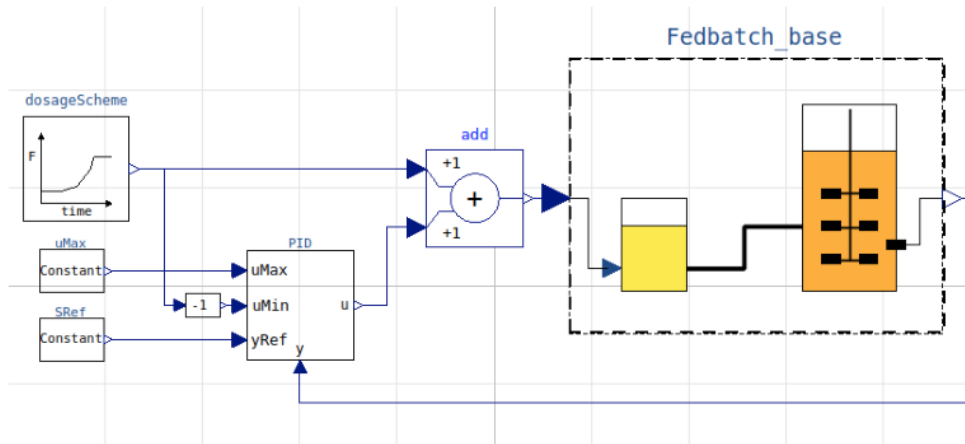
```
%matplotlib inline
plt.rcParams['figure.figsize'] = [25/2.54, 20/2.54]
```

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

▾ BPL_TEST2_Fedbatch - demo

```
process_diagram()
```



```
describe('culture'); print(); #describe('liquidphase')                              # Pump schedule pa
```

> 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
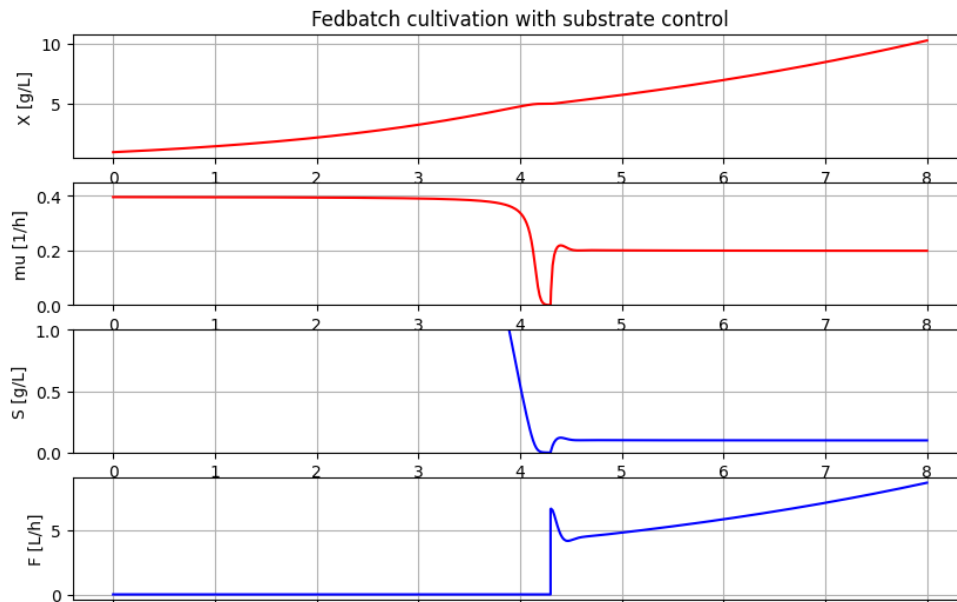

```
disp(mode='long')
```

```
    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', 'substrateRef', 'substrate
```

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

```
    MSL: 3.2.3 - used components: RealInput, RealOutput
```

```
system_info()
```

```
    System information
     -OS: Linux
     -Python: 3.10.12
     -Scipy: not installed in the notebook
     -FMPy: 0.3.15
     -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
     -MSL: 3.2.3
```

```
-Description: Bioprocess Library version 2.1.1
-Interaction: FMU-explore for FMPy version 0.9.8
```

✓　0s　　completed at 20:37　　　　　　　　　　　　　　　　●　✕