⌄ BPL_TEST2_Fedbatch script with FMPy

The key library FMPy is installed.

After the installation a small application BPL_TEST2_Fedbatch 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
```

```
%env PYTHONPATH=
```

```
⇥  env: PYTHONPATH=
```

```
!python --version
```

```
⇥  Python 3.11.11
```

```
!wget https://repo.anaconda.com/miniconda/Miniconda3-py311_24.11.1-0-Linux-x86_64
!chmod +x Miniconda3-py311_24.11.1-0-Linux-x86_64.sh
!bash ./Miniconda3-py311_24.11.1-0-Linux-x86_64.sh -b -f -p /usr/local
import sys
sys.path.append('/usr/local/lib/python3.11/site-packages/')
```

```
⇥  --2025-03-25 09:30:09--  https://repo.anaconda.com/miniconda/Miniconda3-py311
   Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.32.241, 104.16.191.
   Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.32.241|:443... con
   HTTP request sent, awaiting response... 200 OK
   Length: 145900576 (139M) [application/octet-stream]
   Saving to: 'Miniconda3-py311_24.11.1-0-Linux-x86_64.sh'

   Miniconda3-py311_24 100%[===================>] 139.14M   190MB/s    in 0.7s

   2025-03-25 09:30:10 (190 MB/s) - 'Miniconda3-py311_24.11.1-0-Linux-x86_64.sh'

   PREFIX=/usr/local
   Unpacking payload ...

   Installing base environment...

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

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

```
Channels:
 - defaults
Platform: linux-64
Collecting package metadata (repodata.json): done
Solving environment: done

## Package Plan ##

  environment location: /usr/local

  added / updated specs:
    - conda


The following packages will be downloaded:

    package                    |            build
    ---------------------------|-----------------
    ca-certificates-2025.2.25  |       h06a4308_0         129 KB
    certifi-2025.1.31          | py311h06a4308_0         163 KB
    openssl-3.0.16             |       h5eee18b_0         5.2 MB
    ------------------------------------------------------------
                                           Total:         5.5 MB

The following packages will be UPDATED:

  ca-certificates                   2024.11.26-h06a4308_0 --> 2025.2.25-h06a
  certifi                     2024.8.30-py311h06a4308_0 --> 2025.1.31-py31
  openssl                             3.0.15-h5eee18b_0 --> 3.0.16-h5eee18


Downloading and Extracting Packages:
openssl-3.0.16      | 5.2 MB    | :    0% 0/1 [00:00<?, ?it/s]
certifi-2025.1.31   | 163 KB    | :    0% 0/1 [00:00<?, ?it/s]

ca-certificates-2025 | 129 KB    | :    0% 0/1 [00:00<?, ?it/s]

ca-certificates-2025 | 129 KB    | : 100% 1.0/1 [00:00<00:00, 17.55it/s]
openssl-3.0.16      | 5.2 MB    | :   52% 0.5159887533780371/1 [00:00<00:00,

ca-certificates-2025 | 129 KB    | : 100% 1.0/1 [00:00<00:00,  9.92it/s]

ca-certificates-2025 | 129 KB    | : 100% 1.0/1 [00:00<00:00,  9.92it/s]
certifi-2025.1.31   | 163 KB    | : 100% 1.0/1 [00:00<00:00,  9.46it/s]



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

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

```
conda 24.11.1
Python 3.11.11
```

```
!conda config --set channel_priority strict
```

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

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

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

```
#!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/BPL_TEST2_Fedbatch
```

```
⇥  Cloning into 'BPL_TEST2_Fedbatch'...
```

```
%cd BPL_TEST2_Fedbatch
```

```
⇥  /content/BPL_TEST2_Fedbatch
```

```
run -i BPL_TEST2_Fedbatch_fmpy_explore.py
```

```
⇥  Linux - run FMU pre-comiled OpenModelica

    Model for the process 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 simulati
     - 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")
```
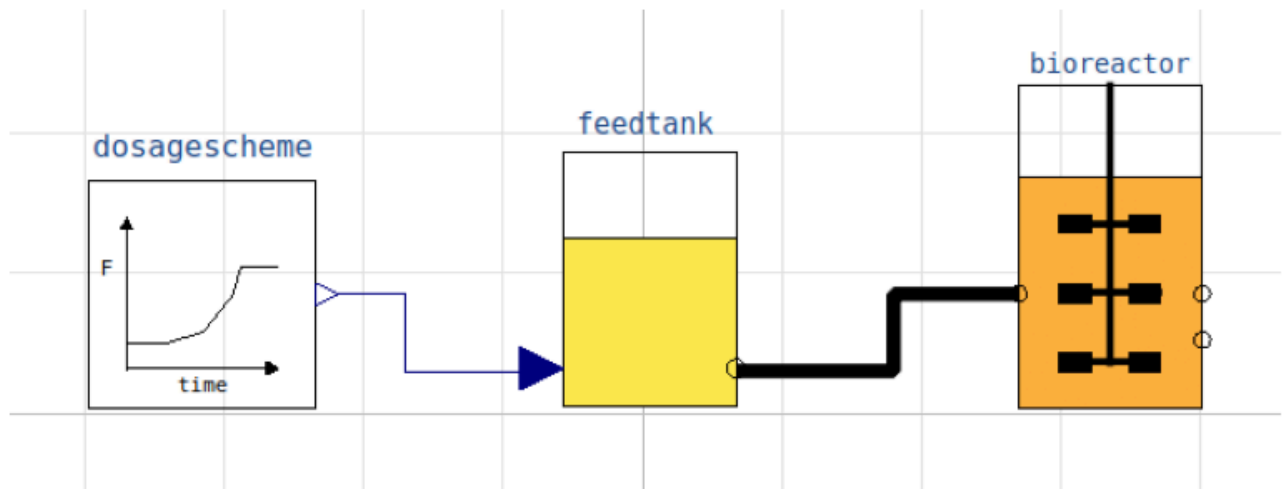
∨ BPL_TEST2_Fedbatch - demo

```
describe('culture'); print(); #describe('liquidphase')
```
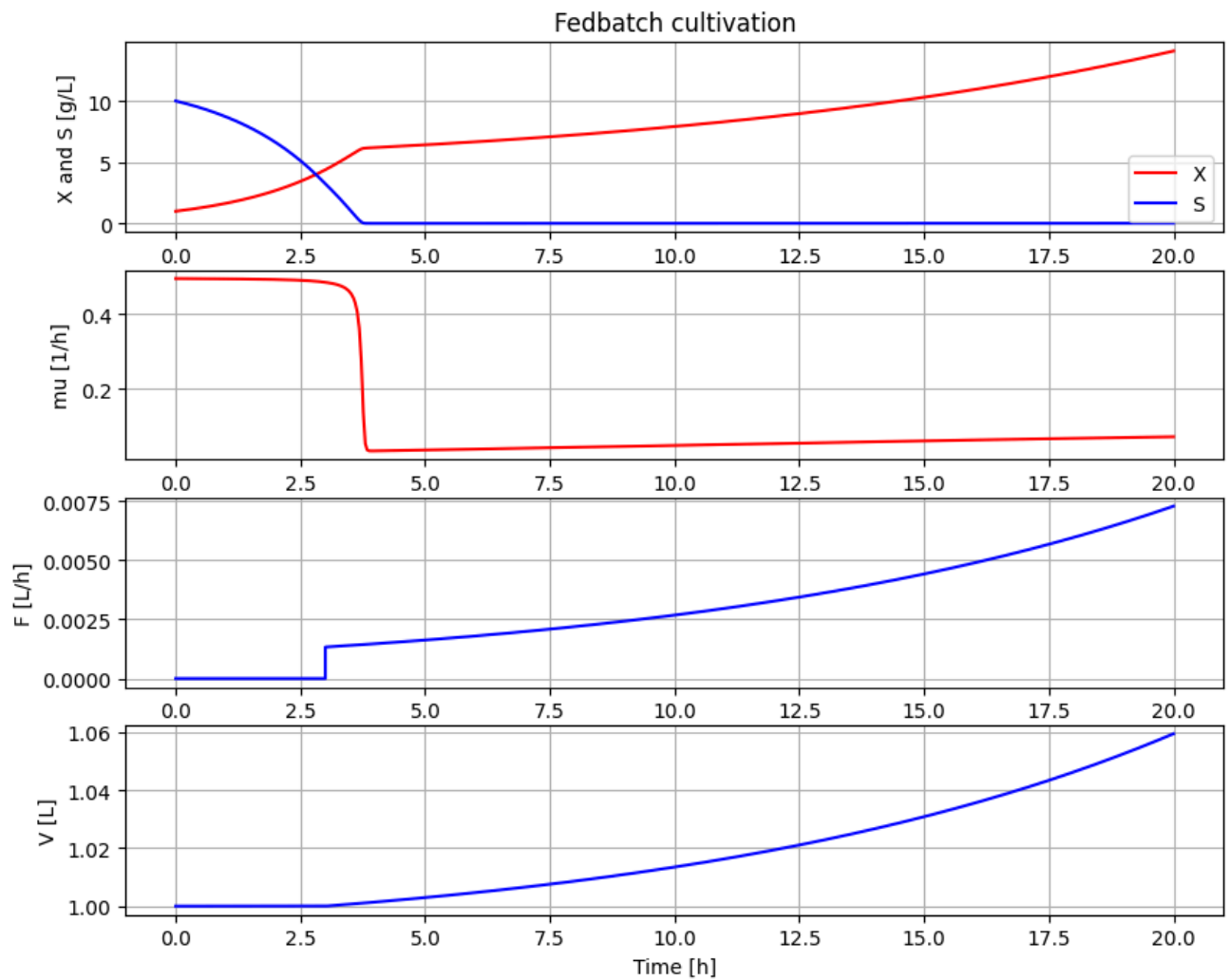
⤇ Simplified text book model — only substrate S and cell concentration X

```
process_diagram()
```

⤇ No processDiagram.png file in the FMU, but try the file on disk.


```
# Simulation with default values of the process
newplot(plotType='TimeSeries')
simu(20)
```

Fedbatch cultivation

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

```
bioreactor.V_start : V_start : 1.0
bioreactor.m_start[1] : VX_start : 0.0
bioreactor.m_start[2] : VS_start : 0.0
bioreactor.culture.Y : Y : 0.5
bioreactor.culture.qSmax : qSmax : 1.0
bioreactor.culture.Ks : Ks : 0.1
feedtank.c_in[2] : feedtank.S_in : 0.0
feedtank.V_start : feedtank.V_start : 100.0
dosagescheme.mu_feed : mu_feed : 0.2
dosagescheme.t_startExp : t_startExp : 2.0
dosagescheme.F_startExp : F_startExp : 0.12
dosagescheme.F_max : F_max : 3.0
```

```
# A more typical feed scheme for the culture at hand
newplot(plotType='TimeSeries')
par(t_startExp=4, F_startExp=0.008, mu_feed=0.2, F_max=0.1)
simu(20)
```

Fedbatch cultivation
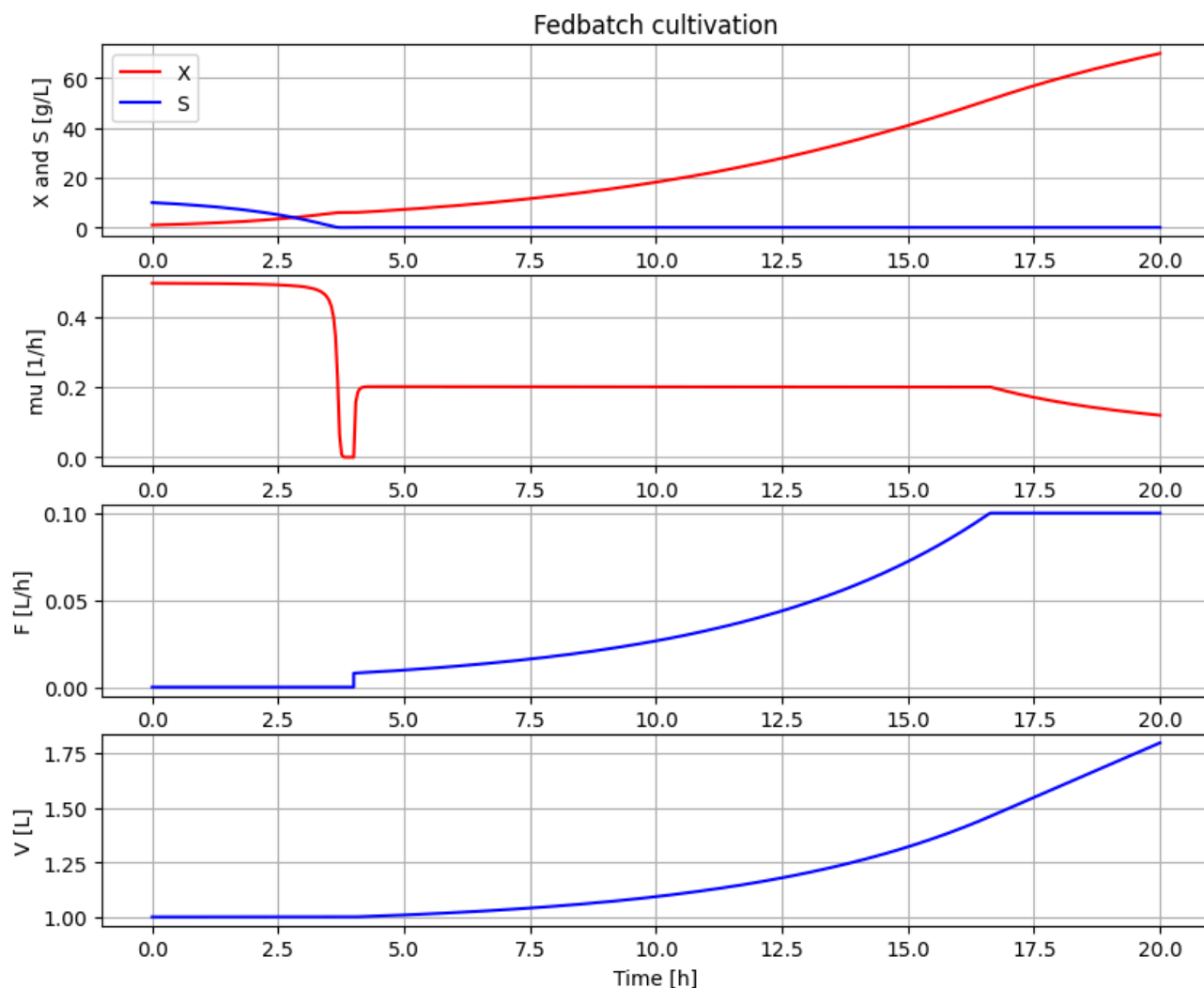
```
disp('culture')
```

Y : 0.5
qSmax : 1.0
Ks : 0.1

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

Cell specific growth rate variable : 0.12 [1/h]

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

['bioreactor', 'bioreactor.culture', 'dosagescheme', 'feedtank']

```
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: 0.3.19
 -FMU by: OpenModelica Compiler OpenModelica 1.25.0~dev-133-ga5470be
 -FMI: 2.0
 -Type: ME
 -Name: BPL.Examples_TEST2.Fedbatch
 -Generated: 2024-11-06T21:37:05Z
 -MSL: 3.2.3
 -Description: Bioprocess Library version 2.3.0
 -Interaction: FMU-explore for FMPy version 1.0.1
```

Start coding or generate with AI.