

## ✓ 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 22.04.3 LTS
   Release:        22.04
   Codename:       jammy
```

```
%env PYTHONPATH=
```

```
⇒ env: PYTHONPATH=
```

```
!wget https://repo.anaconda.com/miniconda/Miniconda3-py312_24.3.0-0-Linux-x86_64.sh
!chmod +x Miniconda3-py312_24.3.0-0-Linux-x86_64.sh
!bash ./Miniconda3-py312_24.3.0-0-Linux-x86_64.sh -b -f -p /usr/local
import sys
sys.path.append('/usr/local/lib/python3.12/site-packages/')
```

```
⇒ --2024-05-21 06:24:39-- https://repo.anaconda.com/miniconda/Miniconda3-py312_24.3.0-0-Linux-x86_64.sh
Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.191.158, 104.16.32.2
Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.191.158|:443... connected
HTTP request sent, awaiting response... 200 OK
Length: 143351488 (137M) [application/octet-stream]
Saving to: 'Miniconda3-py312_24.3.0-0-Linux-x86_64.sh'
```

```
Miniconda3-py312_24 100%[=====] 136.71M 193MB/s in 0.7s
```

```
2024-05-21 06:24:40 (193 MB/s) - 'Miniconda3-py312_24.3.0-0-Linux-x86_64.sh' saved
```

```
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           |        |
|------------------|-----------------|--------|
| conda-24.5.0     | py312h06a4308_0 | 1.2 MB |
| frozendict-2.4.2 | py312h06a4308_0 | 36 KB  |
| openssl-3.0.13   | h7f8727e_1      | 5.2 MB |
| Total:           |                 | 6.5 MB |

The following NEW packages will be INSTALLED:

frozendict pkgs/main/linux-64::frozendict-2.4.2-py312h06a4308\_0

The following packages will be UPDATED:

conda 24.3.0-py312h06a4308\_0 --> 24.5.0-py312h06a4308\_0  
openssl 3.0.13-h7f8727e\_0 --> 3.0.13-h7f8727e\_1

Downloading and Extracting Packages:

|                  |        |   |   |
|------------------|--------|---|---|
| openssl-3.0.13   | 5.2 MB | : | 0% 0/1 [00:00<?, ?it/s]                           |
| conda-24.5.0     | 1.2 MB | : | 0% 0/1 [00:00<?, ?it/s]                           |
| frozendict-2.4.2 | 36 KB  | : | 0% 0/1 [00:00<?, ?it/s]                           |
| openssl-3.0.13   | 5.2 MB | : | 0% 0.002997347135570501/1 [00:00<00:48, 0.00it/s] |
| conda-24.5.0     | 1.2 MB | : | 1% 0.01293349794914382/1 [00:00<00:12, 0.01it/s]  |
| frozendict-2.4.2 | 36 KB  | : | 100% 1.0/1 [00:00<00:00, 3.14it/s]                |
| conda-24.5.0     | 1.2 MB | : | 100% 1.0/1 [00:00<00:00, 1.96it/s]                |

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

!conda --version  
!python --version

conda 24.5.0  
Python 3.12.2

!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-compiled OpenModelica 1.23.0-dev
```

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/un

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")
```

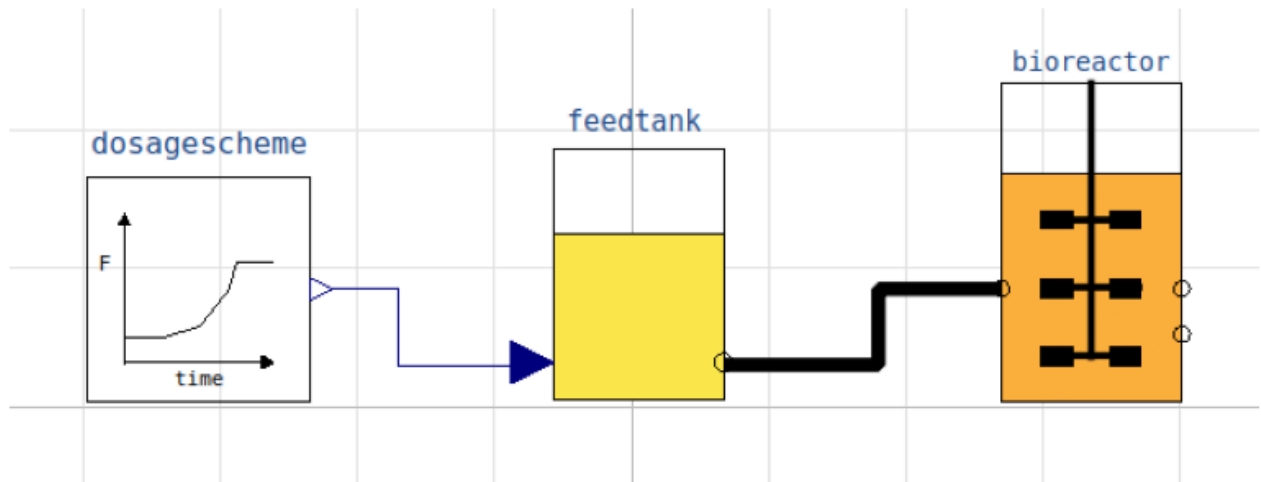
## ✓ BPL\_TEST2\_Fedbatch - demo

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

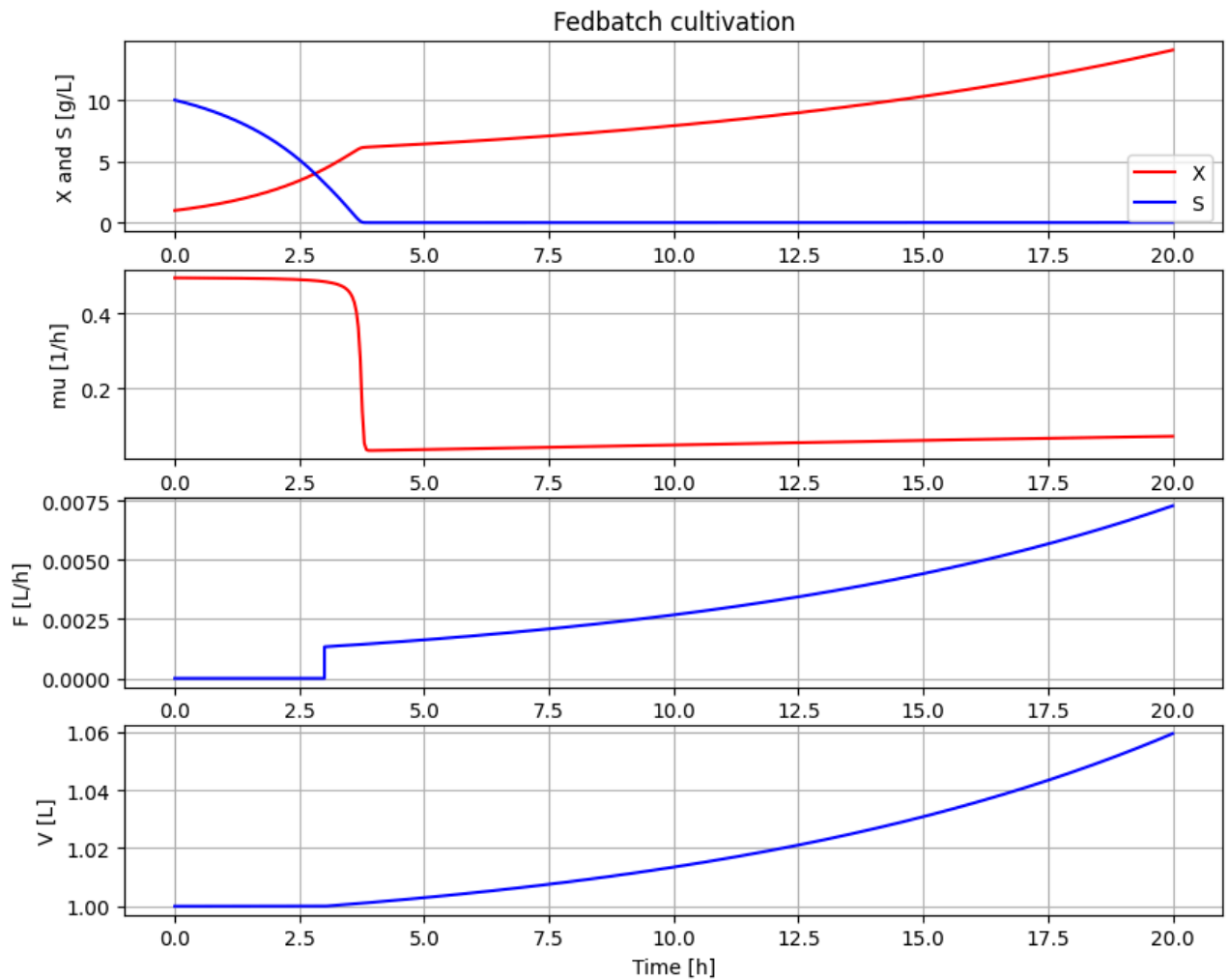
⇒ Simplified text book model – only substrate  $S$  and cell concentration  $X$

```
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)
```



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

```

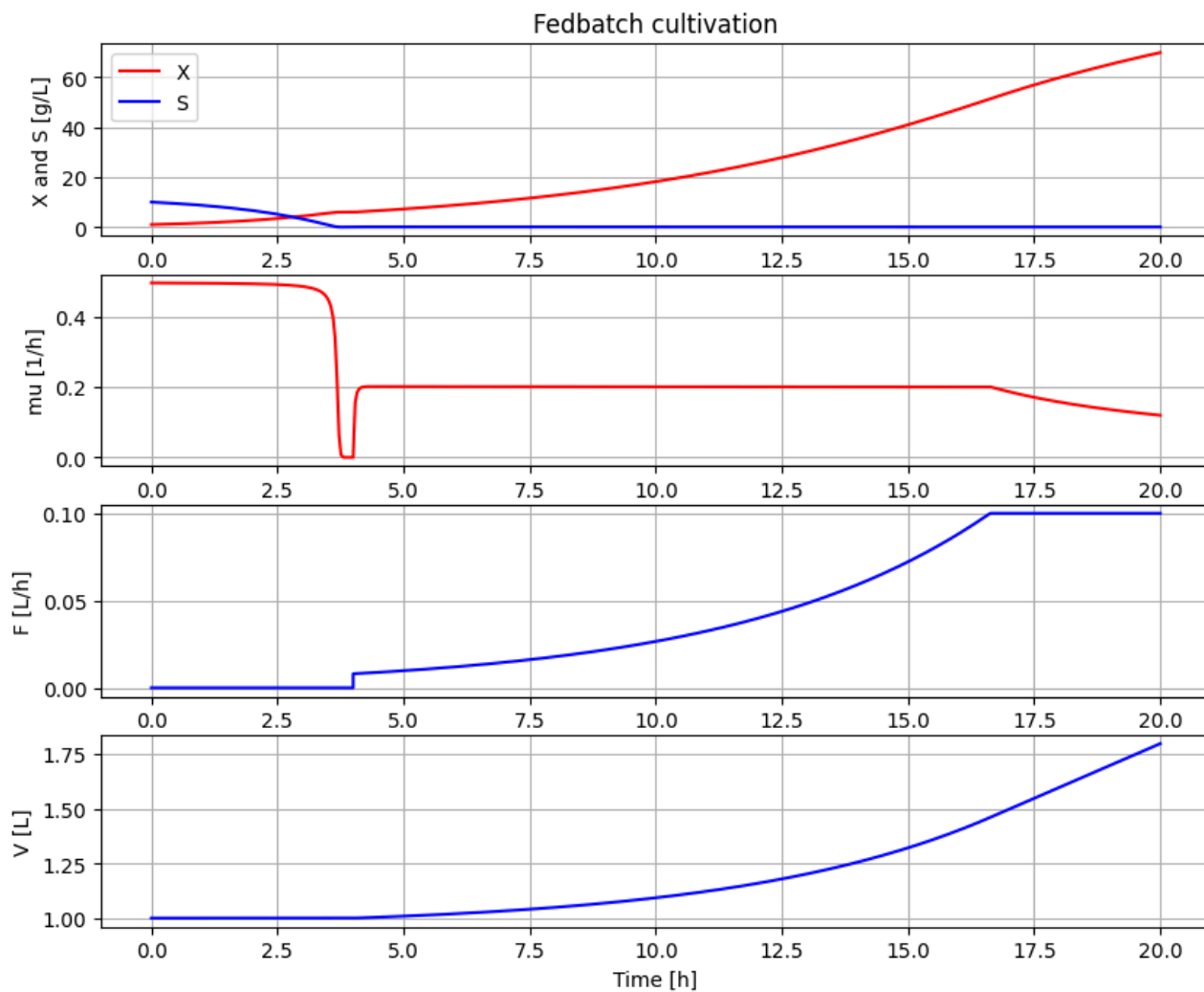
↳ bioreactor.V_start : V_start : 1.0
  bioreactor.m_start[1] : VX_start : 1.0
  bioreactor.m_start[2] : VS_start : 10.0
  bioreactor.culture.Y : Y : 0.5
  bioreactor.culture.qSmax : qSmax : 1.0
  bioreactor.culture.Ks : Ks : 0.1
  feedtank.c_in[2] : feedtank.S_in : 300.0
  feedtank.V_start : feedtank.V_start : 10.0
  dosagescheme.mu_feed : mu_feed : 0.1
  dosagescheme.t_startExp : t_startExp : 3.0
  dosagescheme.F_startExp : F_startExp : 0.001
  dosagescheme.F_max : F_max : 0.3

```

```

# 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)

```



```
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: 3.10.12  
-Scipy: not installed in the notebook  
-FMPy: 0.3.20  
-FMU by: OpenModelica Compiler OpenModelica 1.23.0~dev.beta.1-1-g379f714  
-FMI: 2.0  
-Type: ME  
-Name: BPL\_TEST2.Fedbatch  
C:\Users\user\AppData\Local\Temp\BPL\_TEST2\_Fedbatch\_fmpy\_colab.ipynb