

✓ BPL_TEST2_Fedbatch script with FMPy 0.3.15

The key library FMPy ver 0.3.15 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-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/')

--2024-01-18 09:52:29-- https://repo.anaconda.com/miniconda/Miniconda3-py310\_23.1.0-1-Linux-x86\_64.sh
Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.130.3, 104.16.131.3, 2606:4700::6810:8303, ...
Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.130.3|: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 122MB/s in 0.6s

2024-01-18 09:52:29 (122 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 23.11.0  
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

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

## Package Plan ##

environment location: /usr/local

added / updated specs:
- matplotlib

The following packages will be downloaded:

package | build | size
-----|-----|-----
matplotlib-3.8.0 | py310h06a4308_0 | 8 KB
matplotlib-base-3.8.0 | py310h1128e8f_0 | 6.8 MB
pyparsing-3.0.9 | py310h06a4308_0 | 153 KB
-----|-----|-----
Total: | | 7.0 MB

The following NEW packages will be INSTALLED:

matplotlib pkgs/main/linux-64::matplotlib-3.8.0-py310h06a4308_0

The following packages will be UPDATED:

matplotlib-base conda-forge::matplotlib-base-3.5.2-py~ --> pkgs/main::matplotlib-base-3.8.0-py310h1128e8f_0

The following packages will be SUPERSEDED by a higher-priority channel:

certifi conda-forge/noarch::certifi-2023.11.1~ --> pkgs/main/linux-64::certifi-2023.11.17-py310h06a4308_0
conda conda-forge::conda-23.11.0-py310hff52~ --> pkgs/main::conda-23.11.0-py310h06a4308_0
pyparsing conda-forge/noarch::pyparsing-3.1.1-p~ --> pkgs/main/linux-64::pyparsing-3.0.9-py310h06a4308_0

Downloading and Extracting Packages:
matplotlib-base-3.8.0 | 6.8 MB | : 0% 0/1 [00:00<?, ?it/s]
pyparsing-3.0.9 | 153 KB | : 0% 0/1 [00:00<?, ?it/s]

matplotlib-3.8.0 | 8 KB | : 0% 0/1 [00:00<?, ?it/s]
pyparsing-3.0.9 | 153 KB | : 10% 0.10471552197977783/1 [00:00<00:01, 1.26s/it]

matplotlib-base-3.8.0 | 6.8 MB | : 0% 0.0022928172852449986/1 [00:00<01:08, 68.60s/it]
matplotlib-3.8.0 | 8 KB | : 100% 1.0/1 [00:00<00:00, 7.35it/s]

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/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 1.21.0

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]
```

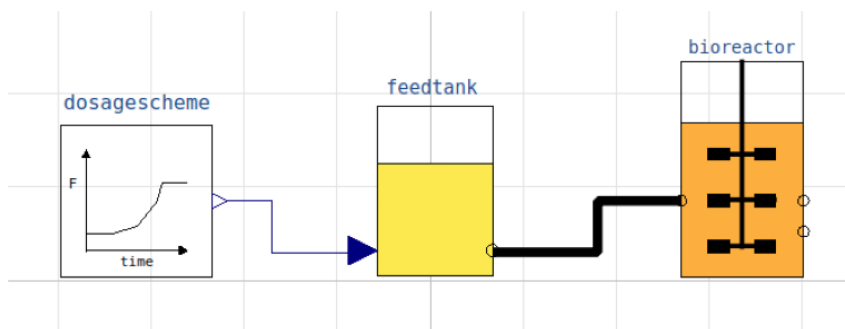
```
import warnings
warnings.filterwarnings("ignore")
```

✓ BPL_TEST2_Fedbatch - demo

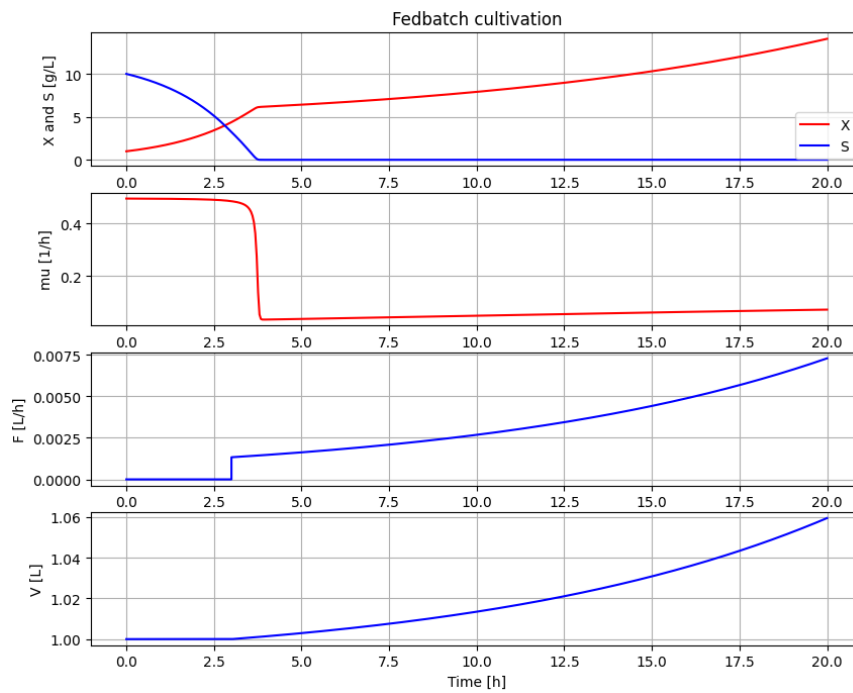
```
describe('culture'); print(); #describe('liquidphase') # Pump schedule parameter
```

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

```
process_diagram()
```



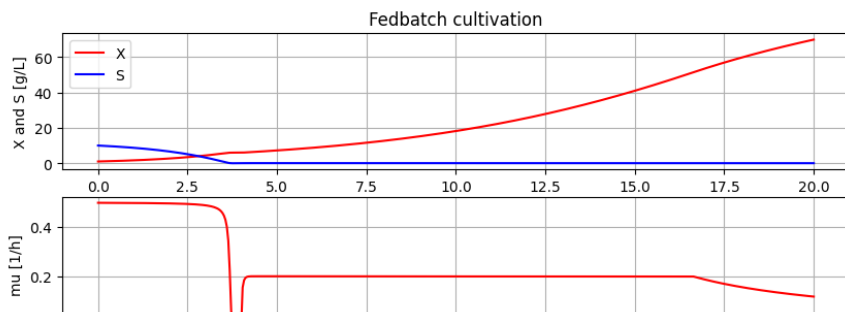
```
# Simulation with default values of the process
newplot(plotType='TimeSeries')
simu(20)
```



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

```
bioreactor.V_0 : V_0 : 1.0
bioreactor.m_0[1] : VX_0 : 1.0
bioreactor.m_0[2] : VS_0 : 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_0 : feedtank.V_0 : 10.0
dosagescheme.mu_feed : mu_feed : 0.1
dosagescheme.t_start : t_start : 3.0
dosagescheme.F_start : F_start : 0.001
dosagescheme.F_max : F_max : 0.3
```

```
# A more typical feed scheme for the culture at hand
newplot(plotType='TimeSeries')
par(t_start=4, F_start=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']
```

```
Time [h]
```

```
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: 0.3.19
-FMU by: OpenModelica Compiler OpenModelica 1.21.0
-FMI: 2.0
-Type: ME
-Name: BPL_TEST2.Fedbatch
-Generated: 2023-04-20T12:24:29Z
-MSL: 3.2.3
-Description: Bioprocess Library version 2.1.1
-Interaction: FMU-explore for FMPy version 0.9.8
```