

## BPL\_TEST2\_Batch script with FMPy

The key library FMPy is installed.

After the installation a small application BPL\_TEST2\_Batch is loaded and run. You can continue with this example if you like.

```
In [1]: !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
```

```
In [2]: !python --version
```

```
Python 3.11.11
```

```
In [3]: !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-packages (from fmpy) (25.3.0)
Requirement already satisfied: Jinja2 in /usr/local/lib/python3.11/dist-packages (from fmpy) (3.1.6)
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 (from fmpy) (5.3.1)
Requirement already satisfied: msgpack in /usr/local/lib/python3.11/dist-packages (from fmpy) (1.1.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packages (from fmpy) (2.0.2)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.11/dist-packages (from Jinja2->fmpy) (3.0.2)
Downloading FMPy-0.3.22-py3-none-any.whl (4.9 MB)
----- 4.9/4.9 MB 30.2 MB/s eta 0:00:00
Downloading lark-1.2.2-py3-none-any.whl (111 kB)
----- 111.0/111.0 kB 7.4 MB/s eta 0:00:00
Installing collected packages: lark, fmpy
Successfully installed fmpy-0.3.22 lark-1.2.2
```

## BPL\_TEST2\_Batch setup

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

- FMU - BPL\_TEST2\_Batch\_linux\_om\_me.fmu
- Setup-file - BPL\_TEST2\_Batch\_fmpy\_explore.py

```
In [4]: %%bash
git clone https://github.com/janpeter19/BPL_TEST2_Batch
```

Cloning into 'BPL\_TEST2\_Batch'...

```
In [5]: %cd BPL_TEST2_Batch

/content/BPL_TEST2_Batch
```

```
In [6]: run -i BPL_TEST2_Batch_fmpy_explore.py
```

Linux - run FMU pre-compiled 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 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()

```
In [7]: %matplotlib inline
plt.rcParams['figure.figsize'] = [25/2.54, 20/2.54]
```

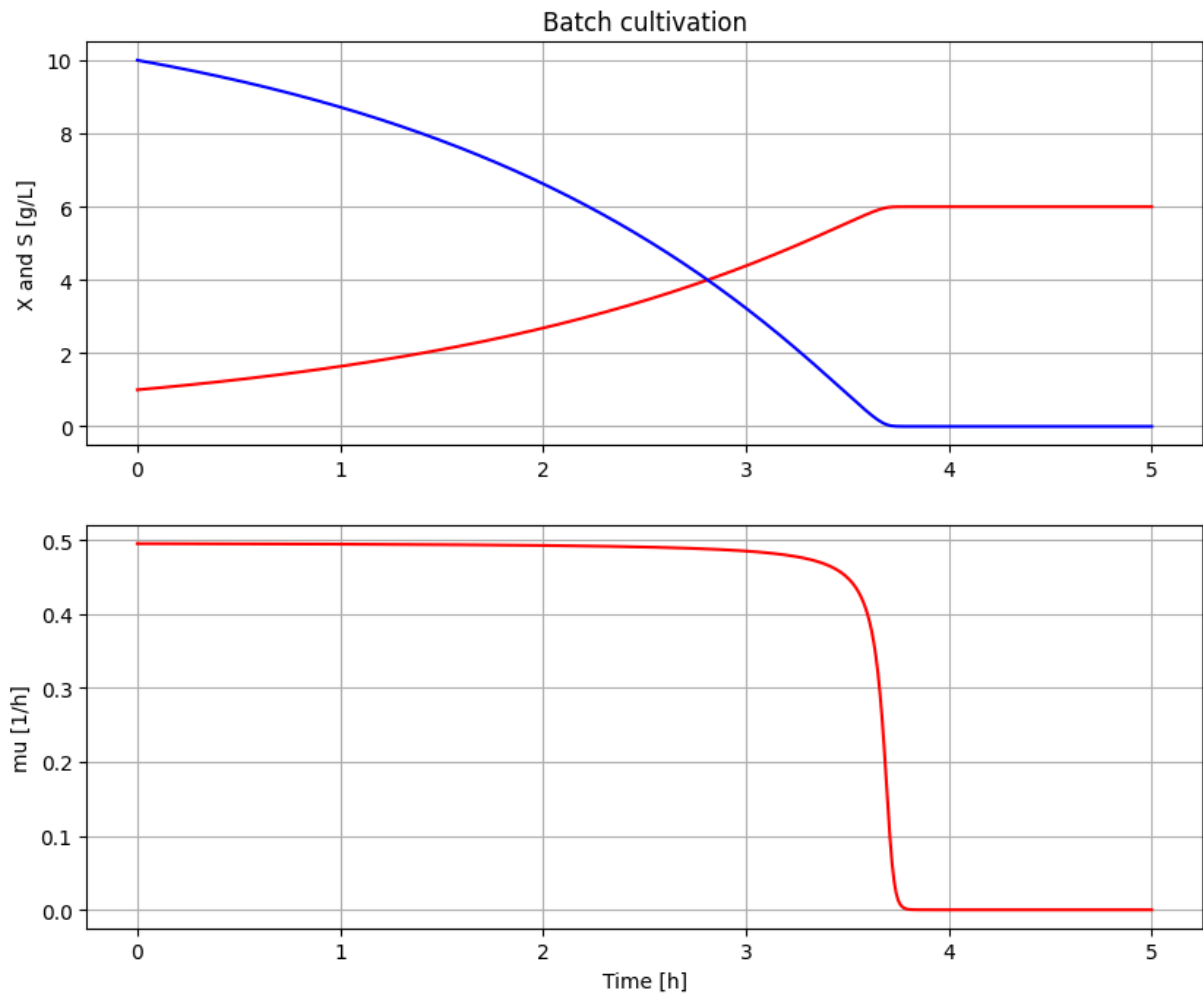
```
In [8]: import warnings
warnings.filterwarnings("ignore")
```

## BPL\_TEST2\_Batch - demo

```
In [9]: describe('culture'); print(); #describe('liquidphase')
```

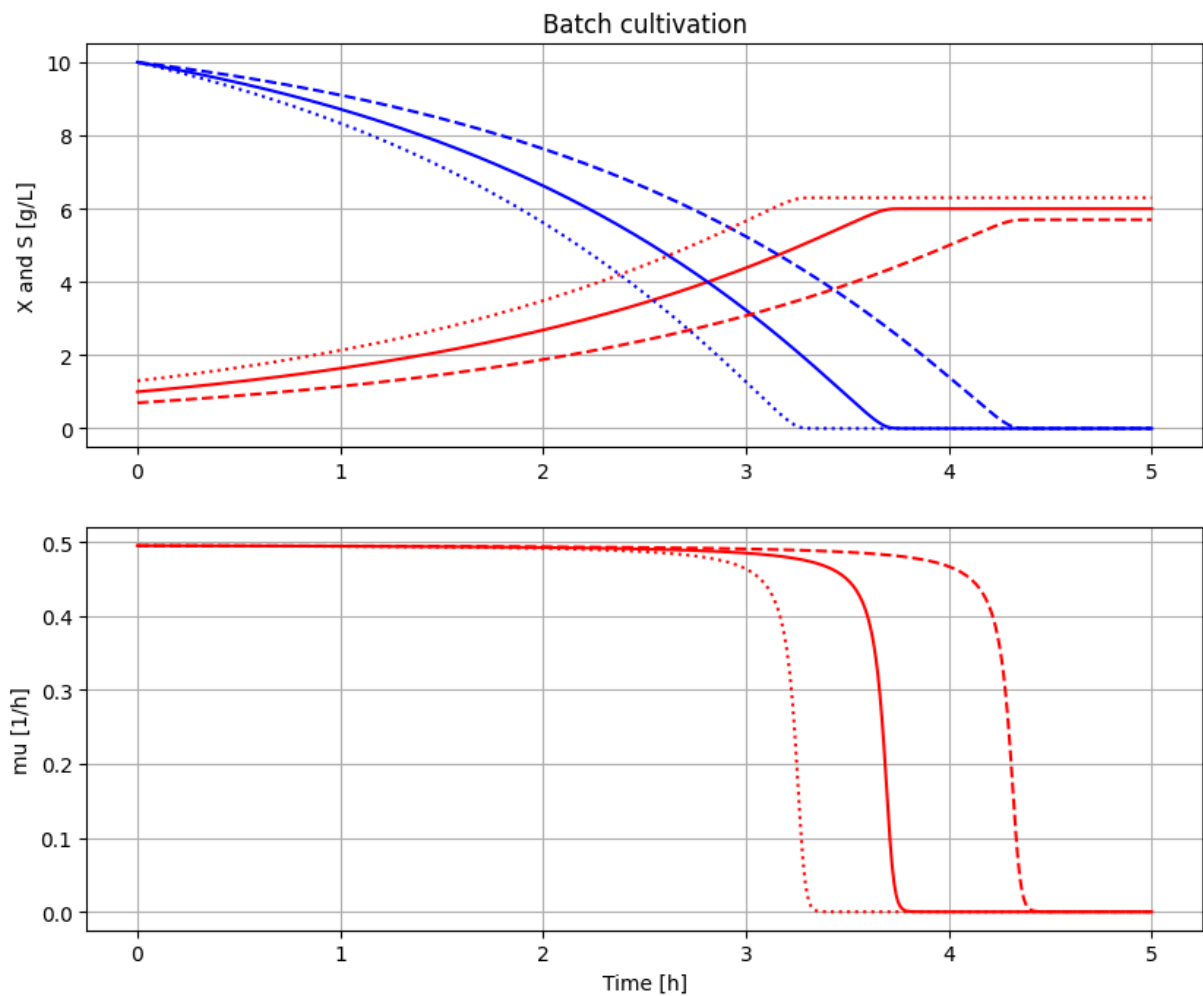
Simplified text book model - only substrate S and cell concentration X

```
In [10]: # Simulation with default values of the process
newplot(plotType='TimeSeries')
simu()
```



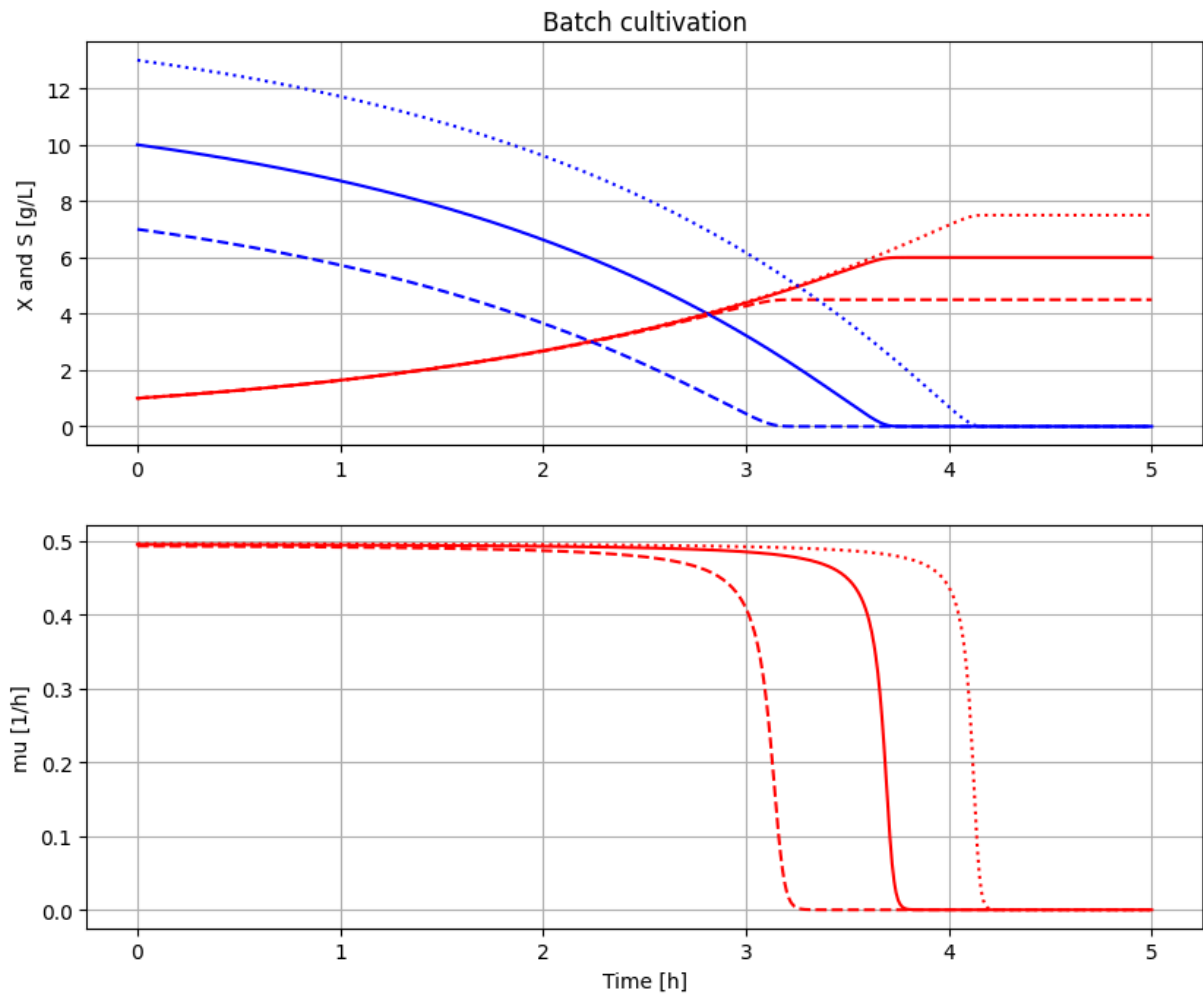
```
In [11]: # Simulation were initial value of biomass VX_start is varied
newplot(plotType='TimeSeries')
for value in [1.0, 0.7, 1.3]: init(VX_start=value); simu(5)

# Restore default value of VX_start
init(VX_start=1.0)
```



```
In [12]: # Simulation were initial value of substrate VS_start is varied
newplot(plotType='TimeSeries')
for value in [10, 7, 13]: init(VS_start=value); simu(5)

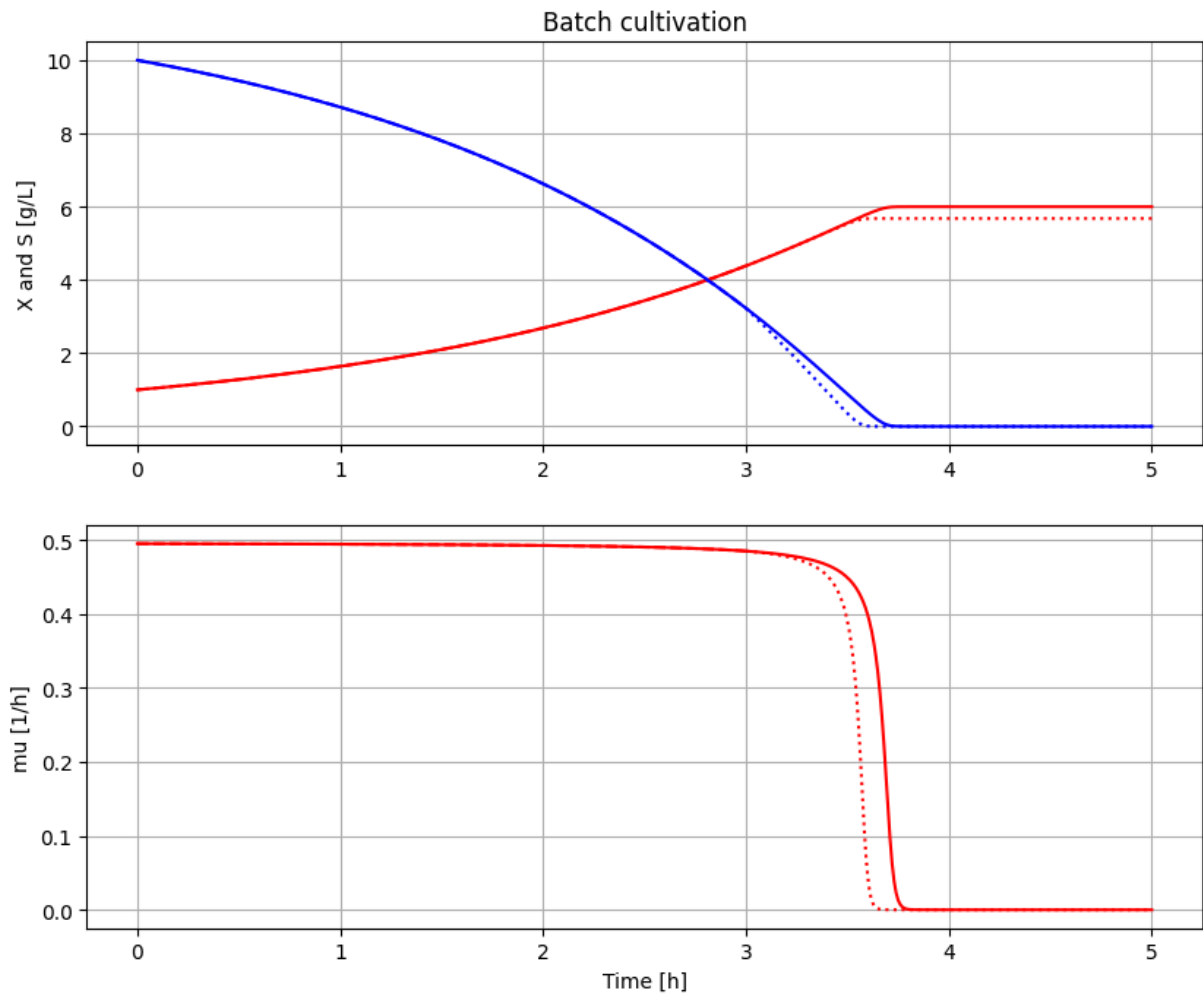
# Restore default value of VS_start
init(VS_start=10)
```



```
In [13]: # Simulation where metabolism is changed after 3 hours
newplot(plotType='TimeSeries')
simu(5)

simu(3)
par(Y=0.4, qSmax=1.0/(0.4/0.5)); simu(2, 'cont')

# Restore default value of Y and qSmax
par(Y=0.5, qSmax=1.0)
```



```
In [14]: disp('culture')
```

```
Y : 0.5
qSmax : 1.0
Ks : 0.1
```

```
In [15]: # Growth rate variable at the end of the cultivation
describe('mu')
```

```
Cell specific growth rate variable : 0.0 [ 1/h ]
```

```
In [16]: describe('parts')
```

```
['bioreactor', 'bioreactor.culture']
```

```
In [17]: describe('MSL')
```

```
MSL: 3.2.3 - used components: none
```

```
In [18]: 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 1.25.0~dev-133-ga5470be
- FMI: 2.0
- Type: ME
- Name: BPL.Examples\_TEST2.Batch
- Generated: 2024-11-06T21:35:34Z
- MSL: 3.2.3
- Description: Bioprocess Library version 2.3.0
- Interaction: FMU-explore for FMPy version 1.0.1

In [18]: