

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.

```
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 # Install the key package
```

```
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 19.7 MB/s eta 0:00:00  
Downloading lark-1.2.2-py3-none-any.whl (111 kB)  
----- 111.0/111.0 kB 8.7 MB/s eta 0:00:00  
Installing collected packages: lark, fmpy  
Successfully installed fmpy-0.3.22 lark-1.2.2
```

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

```
In [4]: %%bash
git clone https://github.com/janpeter19/BPL_TEST2_Fedbatch
```

Cloning into 'BPL_TEST2_Fedbatch'...

```
In [5]: %cd BPL_TEST2_Fedbatch

/content/BPL_TEST2_Fedbatch
```

```
In [6]: run -i BPL_TEST2_Fedbatch_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")
```

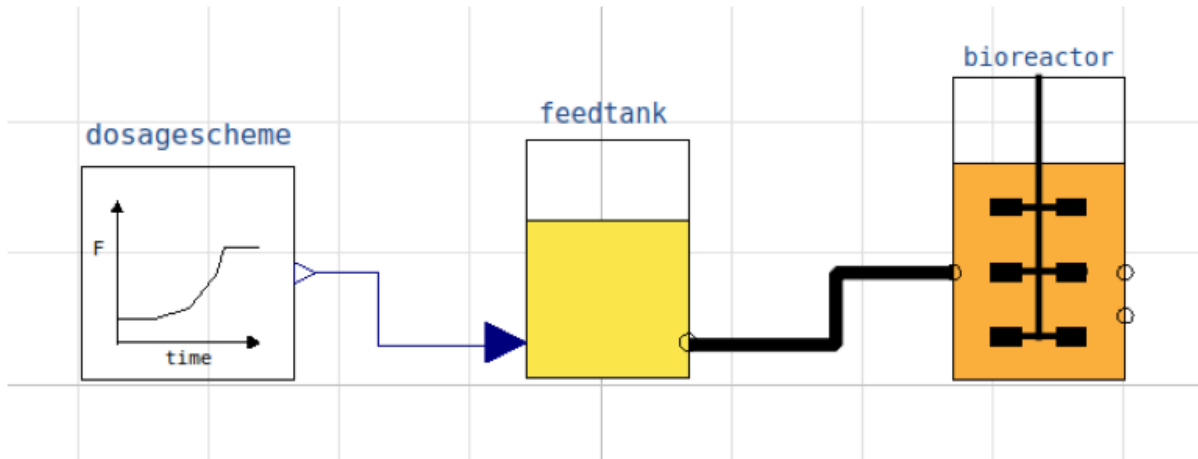
BPL_TEST2_Fedbatch - demo

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

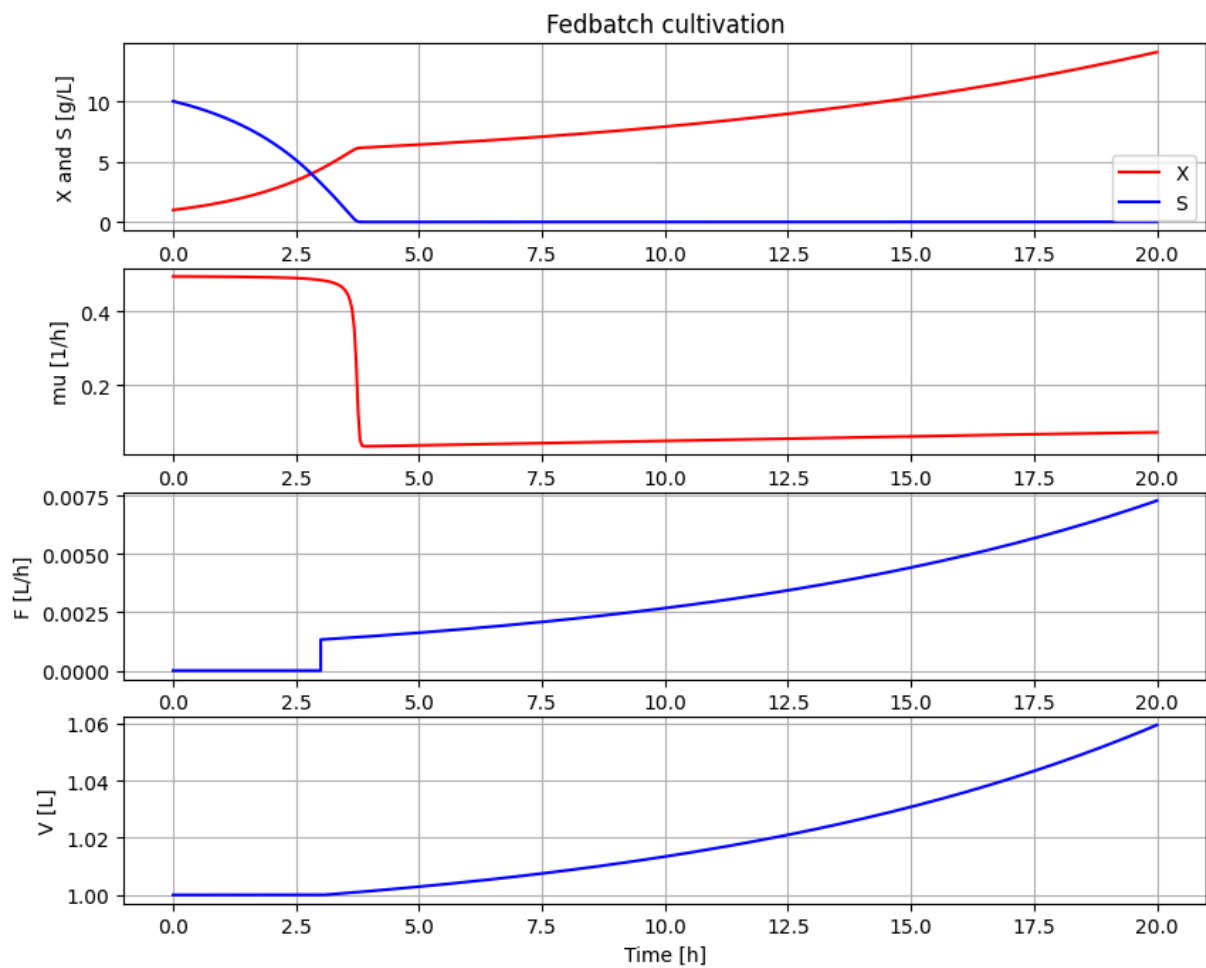
Simplified text book model - only substrate S and cell concentration X

```
In [10]: process_diagram()
```

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



```
In [11]: # Simulation with default values of the process
newplot(plotType='TimeSeries')
simu(20)
```



```
In [12]: disp(mode='long')
```

```

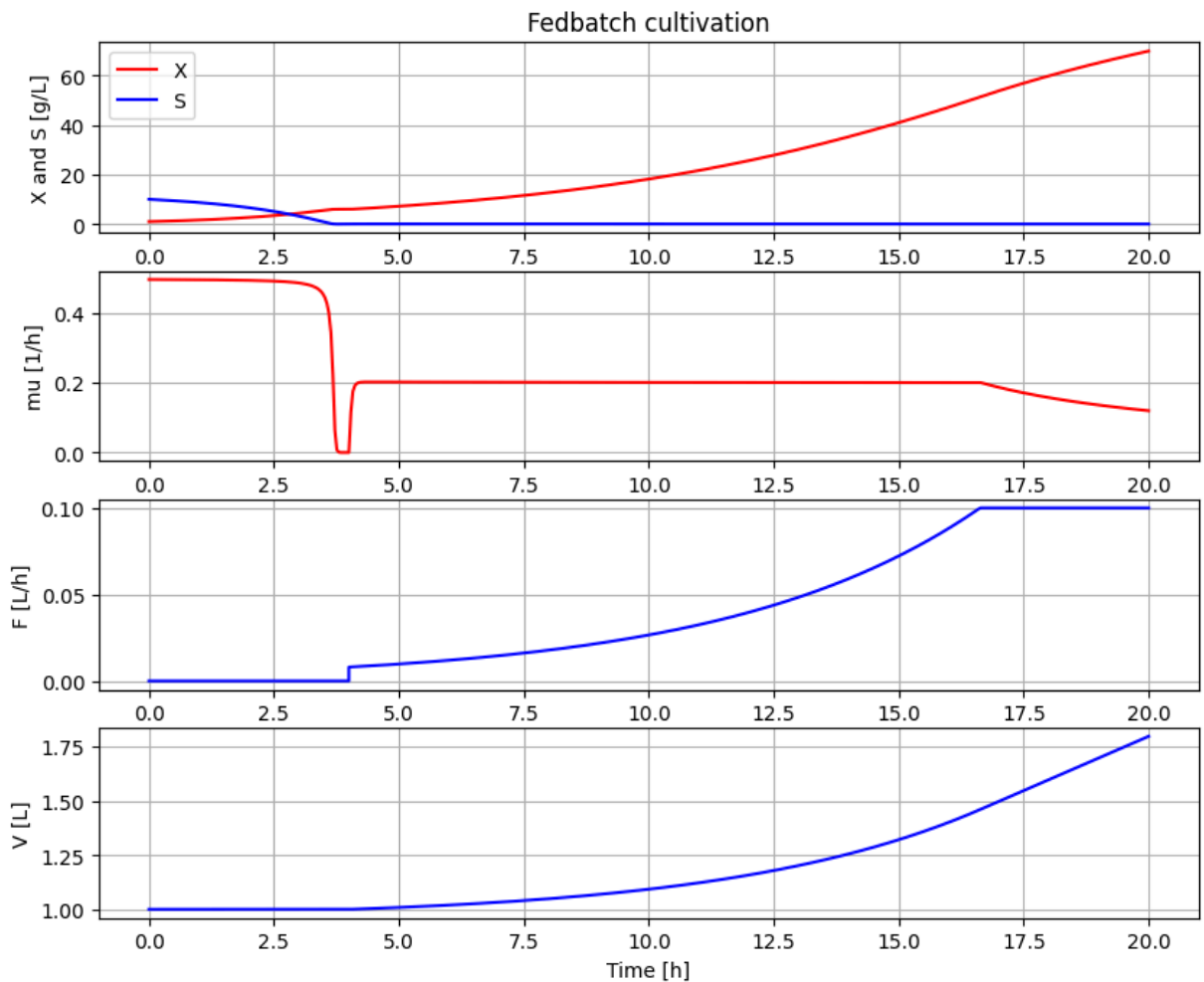
bioreactor.V_start : V_start : 1.0
bioreactor.m_start[1] : VX_start : 0.0
bioreactor.m_start[2] : VS_start : 0.0
bioreactor.culture.Y : Y : 0.5
bioreactor.culture.qSmax : qSmax : 1.0
bioreactor.culture.Ks : Ks : 0.1
feedtank.c_in[2] : feedtank.S_in : 0.0
feedtank.V_start : feedtank.V_start : 100.0
dosagescheme.mu_feed : 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

```

```

In [13]: # 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)

```



```

In [14]: disp('culture')

```

```

Y : 0.5
qSmax : 1.0
Ks : 0.1

```

```

In [15]: describe('mu')

```

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

```
In [16]: describe('parts')  
[ 'bioreactor', 'bioreactor.culture', 'dosagescheme', 'feedtank' ]
```

```
In [17]: describe('MSL')  
MSL: 3.2.3 - used components: RealInput, RealOutput
```

```
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.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
```

```
In [18]:
```