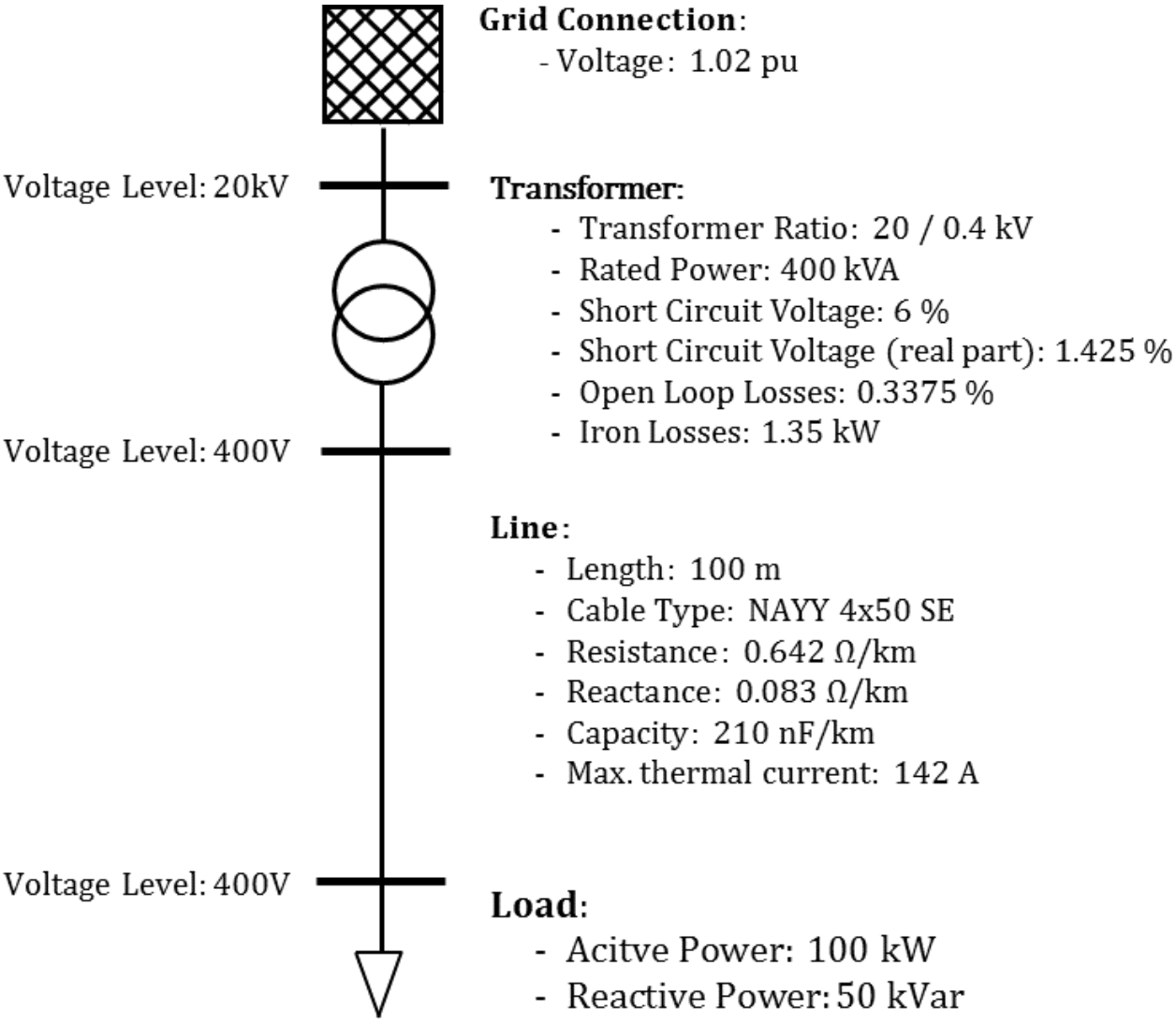
`pandapower` Power Flow (PF) Examples

This is an introduction to the usage of the `pandapower` **power flow** for a 3-bus system. This example is adapted from the `pandapower` tutorial for PF. The installation of `pandapower` is included at the bottom of this script.

Creating a Power System

We consider the following simple 3-bus example network as a minimal example:



The above network can be created in pandapower as follows:

Import and create a network in `pandapower`

In [1]:
```
import pandapower as pp
```

In [2]:
```
net = pp.create_empty_network() # create empty net
```

First, create 3 buses. In `pandapower` these are just empty nodes that we have to fill with something, like a generator, a load, or an external grid.

In [3]:
```
bus1 = pp.create_bus(net, vn_kv=20., name="Bus 1") # Low voltage grid/distribution grid at 20 kV
bus2 = pp.create_bus(net, vn_kv=0.4, name="Bus 2") # Low voltage grid/distribution grid at 400 V
bus3 = pp.create_bus(net, vn_kv=0.4, name="Bus 3") # Low voltage grid/distribution grid at 400 V
```

In [4]:
```
net.bus
```

Out[4]:

	name	vn_kv	type	zone	in_service
0	Bus 1	20.0	b	None	True
1	Bus 2	0.4	b	None	True
2	Bus 3	0.4	b	None	True

Create a load of **100 kW** and **50kVar**.

In [5]:
```
load = pp.create_load(net, element=0, bus=bus3, p_mw=0.100, q_mvar=0.05, name="Load")
```

Now we connect the bus 2 and bus 3 with an AC line of a standard type. Other types are found here.

In [6]:
```
line = pp.create_line_from_parameters(net, from_bus=bus2, to_bus=bus3, length_km=0.1, r_ohm_per_km=0.62
#line = pp.create_line(net, from_bus=bus2, to_bus=bus3, length_km=0.1, std_type='NAYY 4x50 SE', name="L
```

In [7]:
```
net.line
```

Out[7]:

	name	std_type	from_bus	to_bus	length_km	r_ohm_per_km	x_ohm_per_km	c_nf_per_km	g_us_per_km	max_i_ka	c
0	Line	None	1	2	0.1	0.624	0.083	210.0	0.0	0.142	1

Add the *external grid* (`ext_grid`) at bus 1

In [8]:
```
eg = pp.create_ext_grid(net, bus=bus1, vm_pu=1.02, name="Grid Connection")
```

In [9]:
```
net.ext_grid
```

Out[9]:

	name	bus	vm_pu	va_degree	slack_weight	in_service
0	Grid Connection	0	1.02	0.0	1.0	True

And the transformer between bus 1 and bus 2. A list of standard types of transformers is given here.

In [10]:
```
trafo = pp.create_transformer(net, hv_bus=bus1, lv_bus=bus2, std_type="0.4 MVA 20/0.4 kV", name="Trafo"
```

In [11]:
```
net.trafo
```

Out[11]:

	name	std_type	hv_bus	lv_bus	sn_mva	vn_hv_kv	vn_lv_kv	vk_percent	vkr_percent	pfe_kw	i0_percent	shift_degre
0	Trafo	0.4 MVA 20/0.4 kV	0	1	0.4	20.0	0.4	6.0	1.425	1.35	0.3375	150.

Power Flow

We now run a power flow:

In [12]:
```
pp.runpp(net)
```

And check out at the results for buses, lines an transformers:

In [13]:
```
net.res_bus
```

Out[13]:

	vm_pu	va_degree	p_mw	q_mvar
0	1.020000	0.000000	-0.1071	-0.052668
1	1.008849	-0.758789	0.0000	0.000000
2	0.965668	0.082982	0.1000	0.050000

In [14]:
```
net.res_line
```

Out[14]:

	p_from_mw	q_from_mvar	p_to_mw	q_to_mvar	pl_mw	ql_mvar	i_from_ka	i_to_ka	i_ka	vm_from_pu	va_fr
0	0.105228	0.050694	-0.1	-0.05	0.005228	0.000694	0.167111	0.167112	0.167112	1.008849	

In [15]:
```
net.res_trafo
```

Out[15]:

	p_hv_mw	q_hv_mvar	p_lv_mw	q_lv_mvar	pl_mw	ql_mvar	i_hv_ka	i_lv_ka	vm_hv_pu	va_hv_degree	vm_lv_p
0	0.1071	0.052668	-0.105228	-0.050694	0.001872	0.001974	0.003378	0.167111	1.02	0.0	1.00884

A simple example with a generator that can be controlled

In [16]:
```
net = pp.create_empty_network() # create empty net

bus2 = pp.create_bus(net, vn_kv=0.4, name="Bus 2") # Low voltage grid/distribution grid at 400 V
bus3 = pp.create_bus(net, vn_kv=0.4, name="Bus 3") # Low voltage grid/distribution grid at 400 V

#                                                    0.100           0.           0.120
gen = pp.create_gen(net, bus=bus2, name="Generator", p_mw=0.100, min_p_mw=0., max_p_mw=0.120, controlla

#                                         0.110
load = pp.create_load(net, bus=bus3, p_mw=0.100, q_mvar=0.05, name="Load")

#                                                               0.5   is the limit!
line = pp.create_line(net, from_bus=bus2, to_bus=bus3, length_km=0.1, std_type='NAYY 4x50 SE', name="Li
```

In [17]:
```
pp.runpp(net)  # switch to pp.runopp(net) to not surpass the maximum power.
```

Let us check the generator

In [18]:
```
net.res_gen
```

Out[18]:

	p_mw	q_mvar	va_degree	vm_pu
0	0.105498	0.05071	0.0	1.0

And check the load (which is static)

In [19]:
```
net.res_load
```

Out[19]:

	p_mw	q_mvar
0	0.1	0.05

And let us check the line loading

In [20]:
```
net.res_line
#net.line["max_loading_percent"] = 100  # set a limit for the line loading
```

Out[20]:

	p_from_mw	q_from_mvar	p_to_mw	q_to_mvar	pl_mw	ql_mvar	i_from_ka	i_to_ka	i_ka	vm_from_pu	va_fr
0	0.105498	0.05071	-0.1	-0.05	0.005498	0.00071	0.16895	0.168951	0.168951	1.0	

Installation and others

To use `pandapower` it is advised to have `anaconda` / `miniconda` installed. Then either:

```
pip install pandapower
```

or

```
conda install pandapower
```

is enough.

This script was adapted from `pandapower` tutorial for PF for the *FYS377 Digital Power Systems*, by *Heidi S. Nygård*, NMBU. Adapted by Leonardo Rydin Gorjão. 2023.