Hallvar_debug

September 14, 2023

[1]:
```
import dynpssimpy.dynamic as dps
import dynpssimpy.modal_analysis as dps_mdl
import dynpssimpy.plotting as dps_plt
import numpy as np
import matplotlib.pyplot as plt
import json
from sparculing.helper_functions import *
from sparculing.gen_sens import *
```

[2]:
```
# with open('k2a.json') as f:
#     data= f.read()

# model = json.loads(data)
sys = dps.PowerSystemModel('k2a.json')
```

[3]:
```
# pl0 = get_load_power_vector(model)
pl0 = sys.loads['Load'].par['P'].copy()

# pg0=get_gen_power_vector(model)
pg0 = sys.gen['GEN'].par['P'].copy()
```

[4]:
```
np.sum(pg0)
```

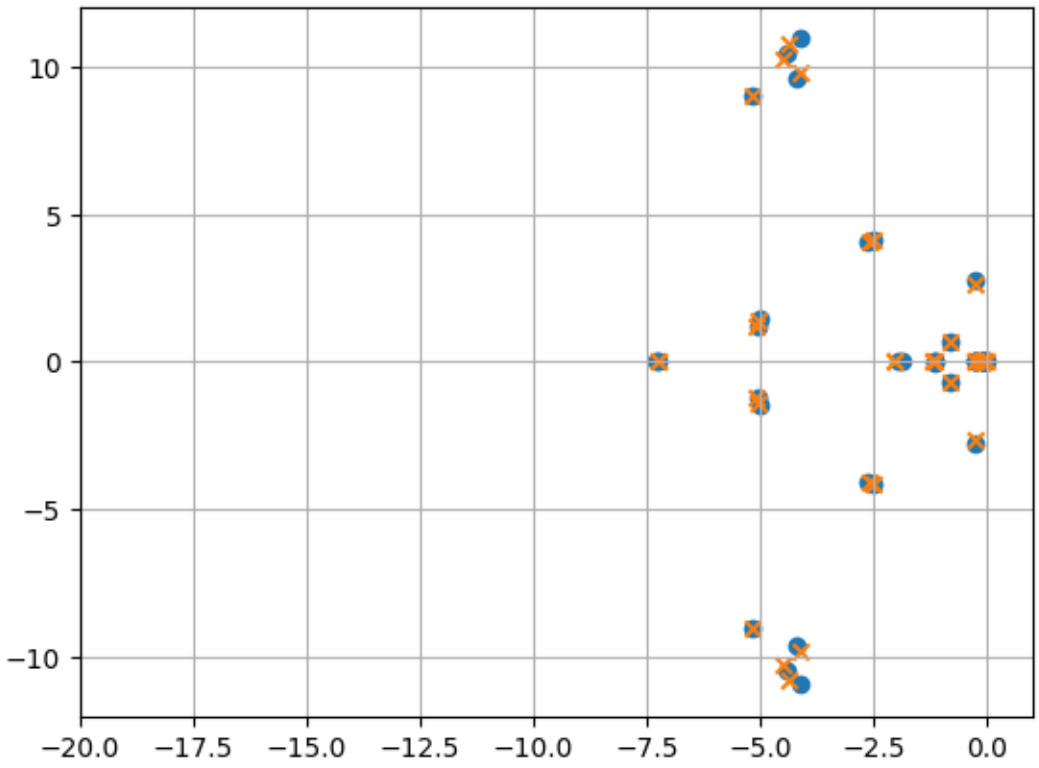
[4]: 2819.0

[5]:
```
sys=dps.PowerSystemModel('k2a.json')
sys.init_dyn_sim()
lin_sys = dps_mdl.PowerSystemModelLinearization(sys)
lin_sys.eigenvalue_decomposition()
eigs_0 = lin_sys.eigs.copy()
print(f"Before load change:\tP_load={sys.loads['Load'].par['P']}\tP_gen={sys.
 ↪gen['GEN'].P_e(sys.x_0, sys.v_0)}")


change_all_load_powers(sys, pl0+[-100,100])

sys.power_flow()
sys.init_dyn_sim()
```

```
lin_sys = dps_mdl.PowerSystemModelLinearization(sys)
lin_sys.eigenvalue_decomposition()
eigs_1 = lin_sys.eigs.copy()


print(f"After load change:\tP_load={sys.loads['Load'].par['P']}\tP_gen={sys.
  ↪gen['GEN'].P_e(sys.x_0, sys.v_0)}")
# print(sys.s_0)

fig, ax = plt.subplots(1)
plt.grid()
ax.scatter(eigs_0.real, eigs_0.imag)
ax.scatter(eigs_1.real, eigs_1.imag, marker='x')
ax.set_xlim(-20, 1)

# print(eigs_0 - eigs_1)
```

```
Before load change:     P_load=[ 967. 1767.]    P_gen=[700.          700.
719.09238061 700.        ]
After load change:      P_load=[ 867. 1867.]    P_gen=[700.          700.
734.76688469 700.        ]
```

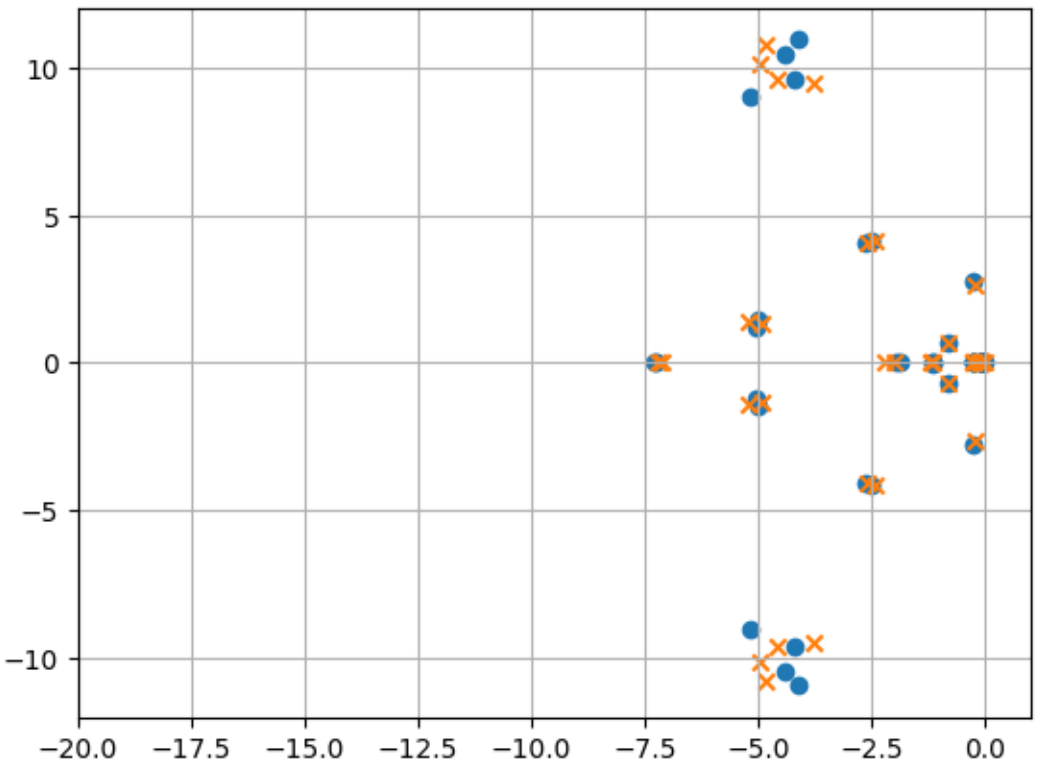
[5]: (-20.0, 1.0)



[6]:
```
change_all_load_powers(sys, pl0)
```

[7]:
```
sys=dps.PowerSystemModel('k2a.json')
sys.init_dyn_sim()
print(f"Before load change:\tP_load={sys.loads['Load'].par['P']}\tP_gen={sys.
  ↪gen['GEN'].P_e(sys.x_0, sys.v_0)}")

# sys.power_flow()
# sys.init_dyn_sim()
# lin_sys = dps_mdl.PowerSystemModelLinearization(sys)
# lin_sys.eigenvalue_decomposition()
lin_sys = get_lin_sys(sys)
eigs_0 = lin_sys.eigs.copy()



change_all_gen_powers(sys, pg0+[100,0,0,-100])
sys.power_flow()
sys.init_dyn_sim()
print(f"After load change:\tP_load={sys.loads['Load'].par['P']}\tP_gen={sys.
  ↪gen['GEN'].P_e(sys.x_0, sys.v_0)}")

# sys.power_flow()
# sys.init_dyn_sim()
# lin_sys = dps_mdl.PowerSystemModelLinearization(sys)
# lin_sys.eigenvalue_decomposition()
lin_sys = get_lin_sys(sys)
eigs_1 = lin_sys.eigs.copy()

fig, ax = plt.subplots(1)
plt.grid()
ax.scatter(eigs_0.real, eigs_0.imag)
ax.scatter(eigs_1.real, eigs_1.imag, marker='x')
ax.set_xlim(-20, 1)

change_all_gen_powers(sys, pg0)
```

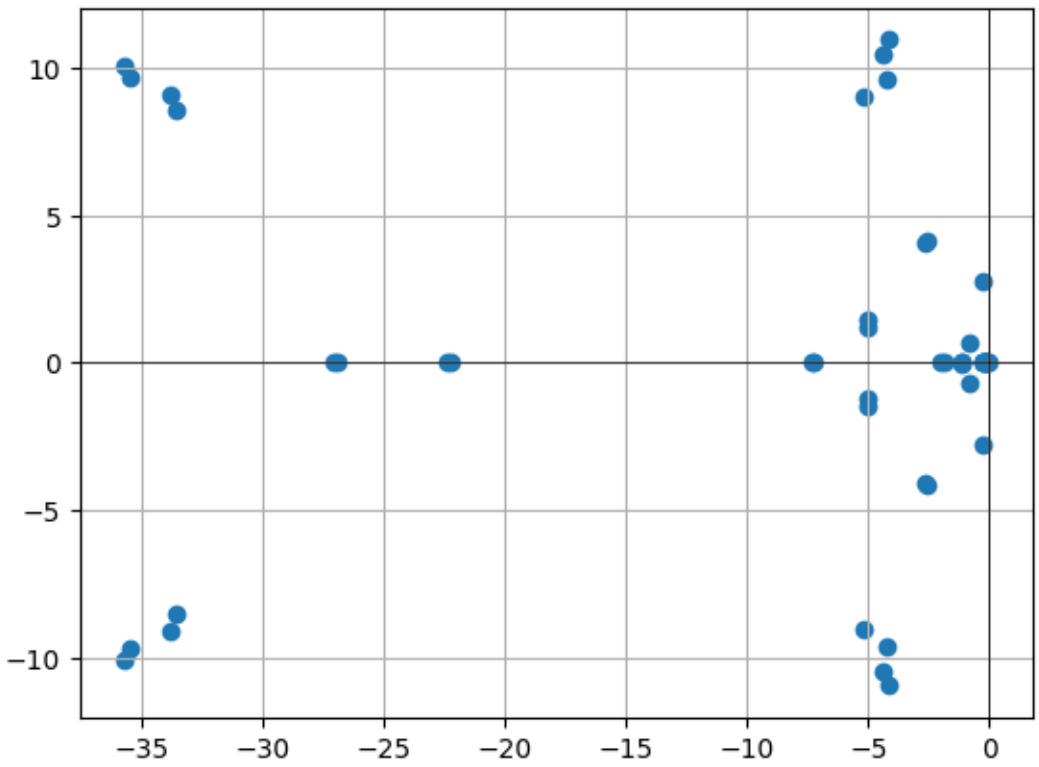
```
Before load change:     P_load=[ 967. 1767.]    P_gen=[700.         700.
719.09238061 700.        ]
After load change:      P_load=[ 967. 1767.]    P_gen=[800.         700.
738.50497797 600.        ]
```



[ ]:

[8]:
```
sys=dps.PowerSystemModel('k2a.json')
sys.init_dyn_sim()
ps_lin = dps_mdl.PowerSystemModelLinearization(sys)
ps_lin.linearize()
ps_lin.eigenvalue_decomposition()
```

[9]:
```
dps_plt.plot_eigs(ps_lin.eigs)
```



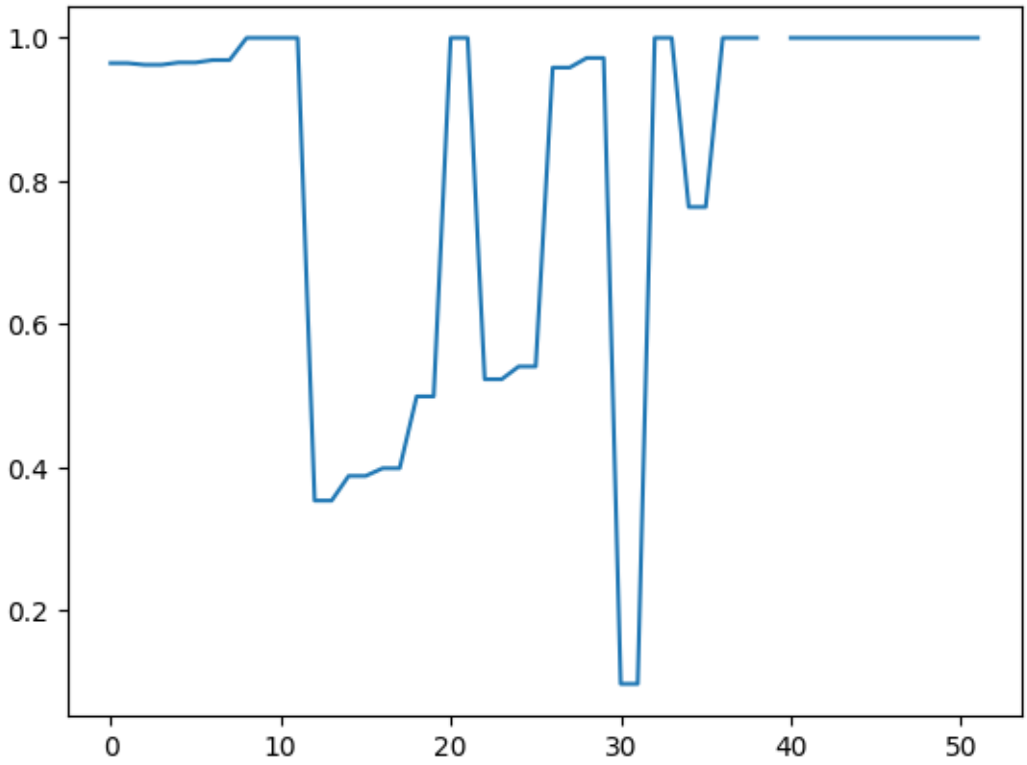
[10]:
```
remove_inaccurate_zero(ps_lin)
```

[11]:
```
np.argmin(ps_lin.damping)
```

[11]: 30

[12]:
```
plt.plot(ps_lin.damping)
```

[12]: [<matplotlib.lines.Line2D at 0x7f1dd4682a50>]



[13]:
```
np.min(ps_lin.damping)
```

[13]:
```
0.09737555264332509
```

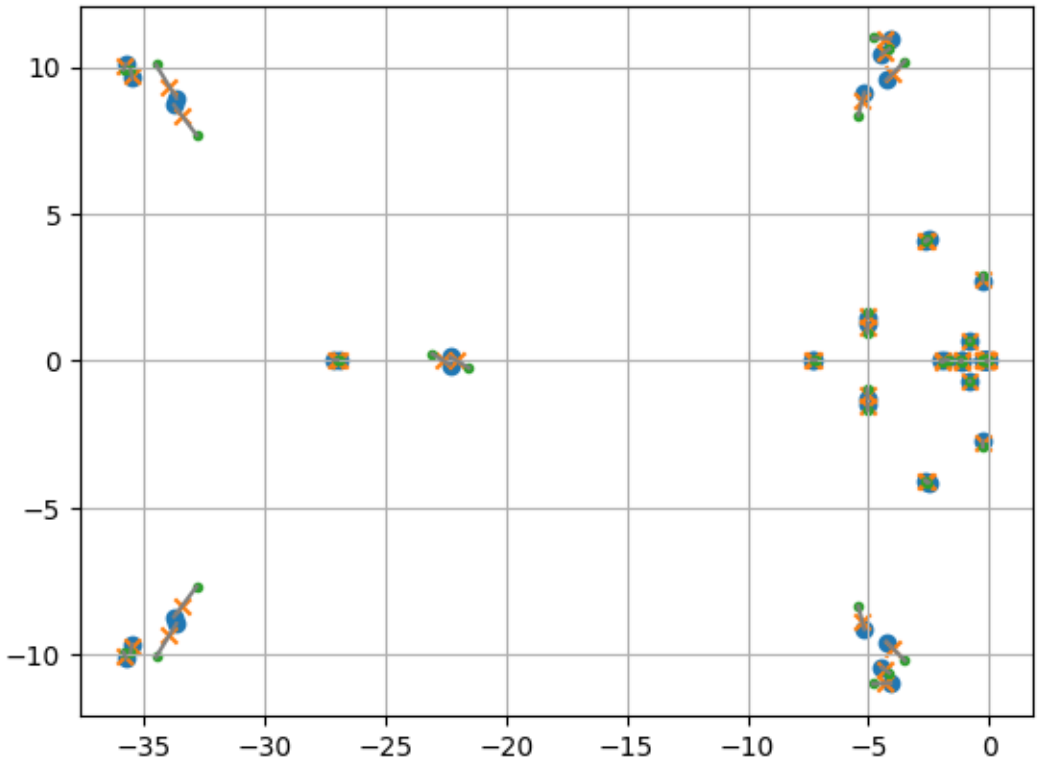
[14]:
```
senser = GenSensDispatchUnconstrained(sys)
```

[15]:
```
# np.shape(senser.gen_sens)
```

[16]:
```
dP = 2e-2
sens_single_gen, eigs_0, eigs_1 =senser.get_gen_sens_single_gen(0, dP=dP,␣
 ↪return_eigs=True)
```

[17]:
```
#genser = eigs_0 - eigs_1
eigs_pred = eigs_0 - sens_single_gen*dP*.5e4
linear_locus = np.vstack([eigs_0, eigs_pred]).T
eig_idx = slice(None)  # 10,17)  # 7, 8)
# print(np.argmin(np.abs(eigs_0 + 5 - 8j)))
# print(eigs_0[16])

plt.scatter(eigs_0[eig_idx].real, eigs_0[eig_idx].imag)
plt.scatter(eigs_1[eig_idx].real, eigs_1[eig_idx].imag, marker='x')
plt.scatter(eigs_pred[eig_idx].real, eigs_pred[eig_idx].imag, marker='.')
```

```
for line in linear_locus[eig_idx]:
    plt.plot(line.real, line.imag, color='gray')
# plt.xlim([-10, 1])
# plt.ylim([-10, 10])
plt.grid()
```



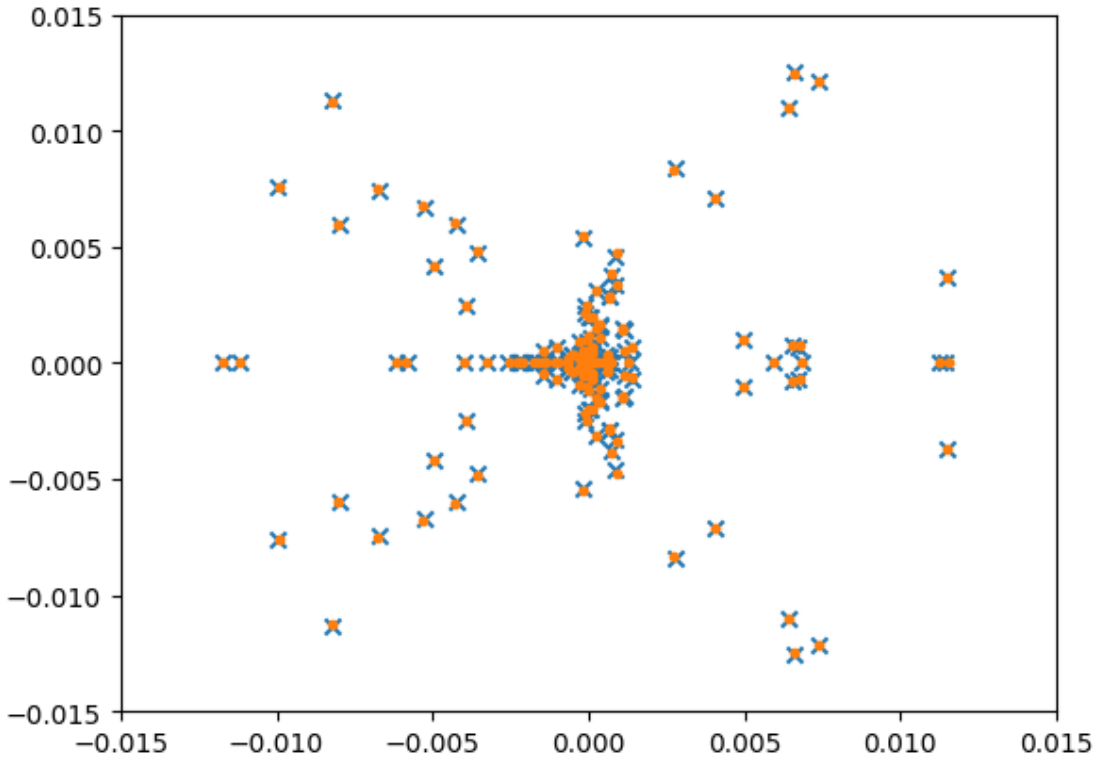
[18]:
```
print(np.angle(eigs_0 - eigs_1)[0])
print(np.angle(sens_single_gen[0]))
```

```
-1.350568651634437
-1.350568651634437
```

[19]:
```
genser = senser.get_gen_sens(dP=2e-4)
genser2=senser.get_gen_sens(dP=3e-4)
#genser3=senser.get_gen_sens(dP=1e-4)
#genser4=senser.get_gen_sens(dP=1e-3)
#genser5=senser.get_gen_sens(dP=1e-2)

# np.max(abs(genser2-genser3))
plt.scatter(genser.real, genser.imag, marker='x')
plt.scatter(genser2.real, genser2.imag, marker='.')
# plt.scatter(genser3.real, genser3.imag, marker='.')
```

```
# plt.scatter(genser4.real, genser4.imag, marker='.')
# plt.scatter(genser4.real, genser5.imag, marker='.')
plt.xlim([-0.015, 0.015])
plt.ylim([-0.015, 0.015])
```

[19]: (-0.015, 0.015)



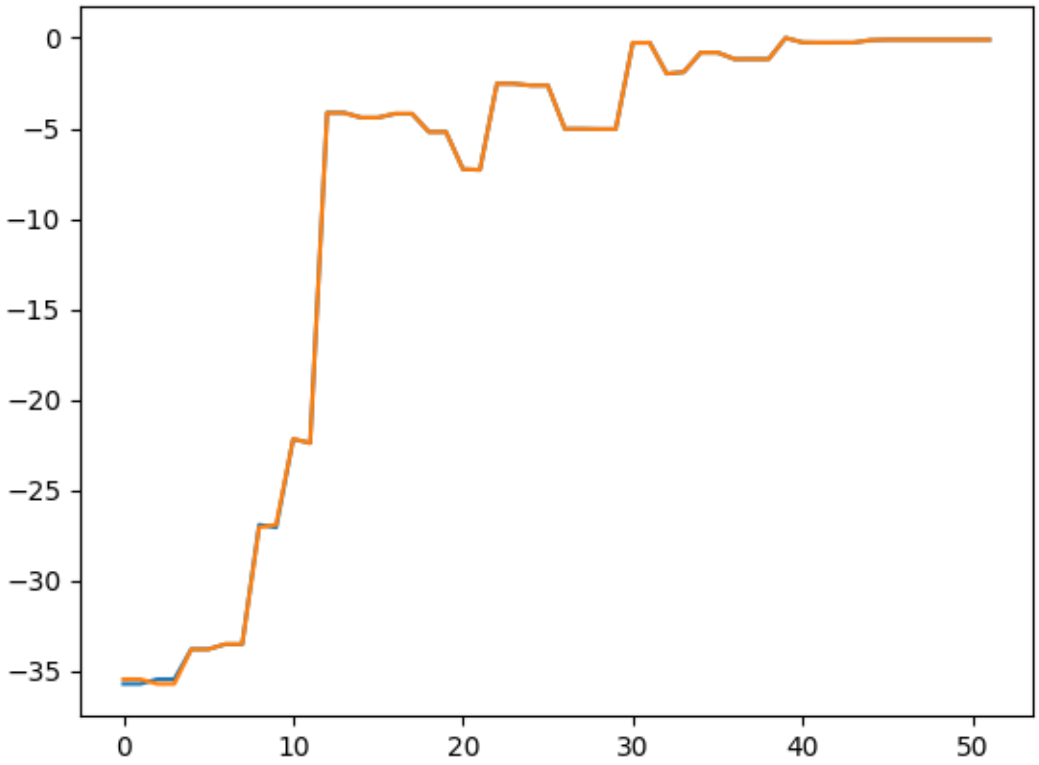
[ ]:

[20]:
```
self = senser
gen_i = 1
dP = 1e-3

sens = np.zeros(len(self.eigs_0), dtype=complex)
rating = self.ratings[gen_i]

change = rating * dP

powers = self._change_power_with_distributed_slack(change, gen_i)
print(powers)
change_all_gen_powers(self.ps, powers)
print(f"self.ps.gen['GEN'].par['P']={self.ps.gen['GEN'].par['P']}")
```

```
ps_lin = get_lin_sys(self.ps)
remove_inaccurate_zero(ps_lin)
sens = ps_lin.eigs.copy()
eigs_0 = ps_lin.eigs.copy()
# print(eigs_0[0])

powers = self._change_power_with_distributed_slack(-2 * change, gen_i)
print(powers)
change_all_gen_powers(self.ps, powers)

ps_lin = get_lin_sys(self.ps)
remove_inaccurate_zero(ps_lin)

sens -= ps_lin.eigs
print(sens[0])
sens = sens / (self.ratings[gen_i] * 2 * dP)
eigs_1 = ps_lin.eigs.copy()
print(f'abs(eigs)={abs(eigs_1[0] - eigs_0[0])}')

plt.plot(eigs_0)
plt.plot(eigs_1)
plt.show()

powers = self._change_power_with_distributed_slack(change, gen_i)
change_all_gen_powers(self.ps, powers)
# print(sens[0])
```

```
[700.3 700.9 719.3 700.3]
self.ps.gen['GEN'].par['P']=[700.3 700.9 719.3 700.3]
[699.4 698.2 718.4 699.4]
(-0.25355156252440736+0.4020372693143983j)
abs(eigs)=0.4753129082786901
```

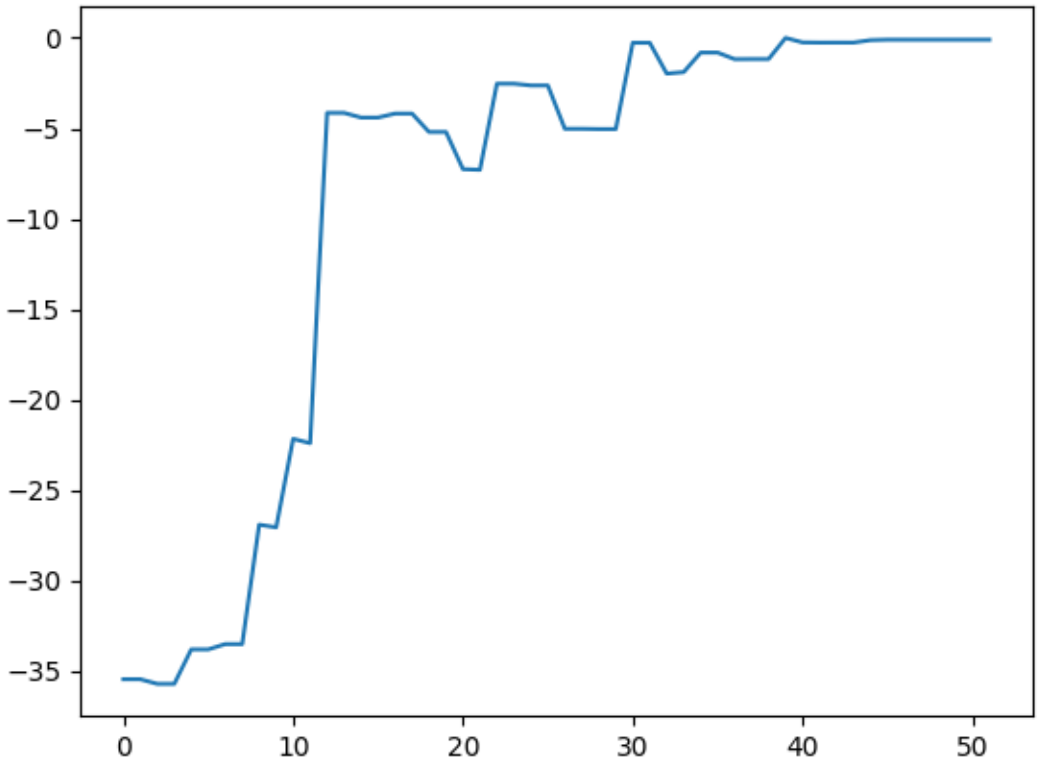
```
/home/sigurd/git_repos/bayes_rescheduling/.venv/lib/python3.11/site-
packages/matplotlib/cbook/__init__.py:1335: ComplexWarning: Casting complex
values to real discards the imaginary part
  return np.asarray(x, float)
```



[21]:
```
sens = np.zeros(len(self.eigs_0), dtype=complex)
rating = self.ratings[gen_i]

change = rating * dP
powers = self._change_power_with_distributed_slack(change, gen_i)
change_all_gen_powers(self.ps, powers)

ps_lin = get_lin_sys(self.ps)
remove_inaccurate_zero(ps_lin)
eigs_1 = ps_lin.eigs.copy()
print(eigs_1[0])
eigs_1 = match_eigenvalues(self.eigs_0, eigs_1)
print(eigs_1[0])
sens = eigs_1.copy()

powers = self._change_power_with_distributed_slack(-2 * change, gen_i)

change_all_gen_powers(self.ps, powers)

ps_lin = get_lin_sys(self.ps)
remove_inaccurate_zero(ps_lin)
eigs_2 = ps_lin.eigs.copy()
```

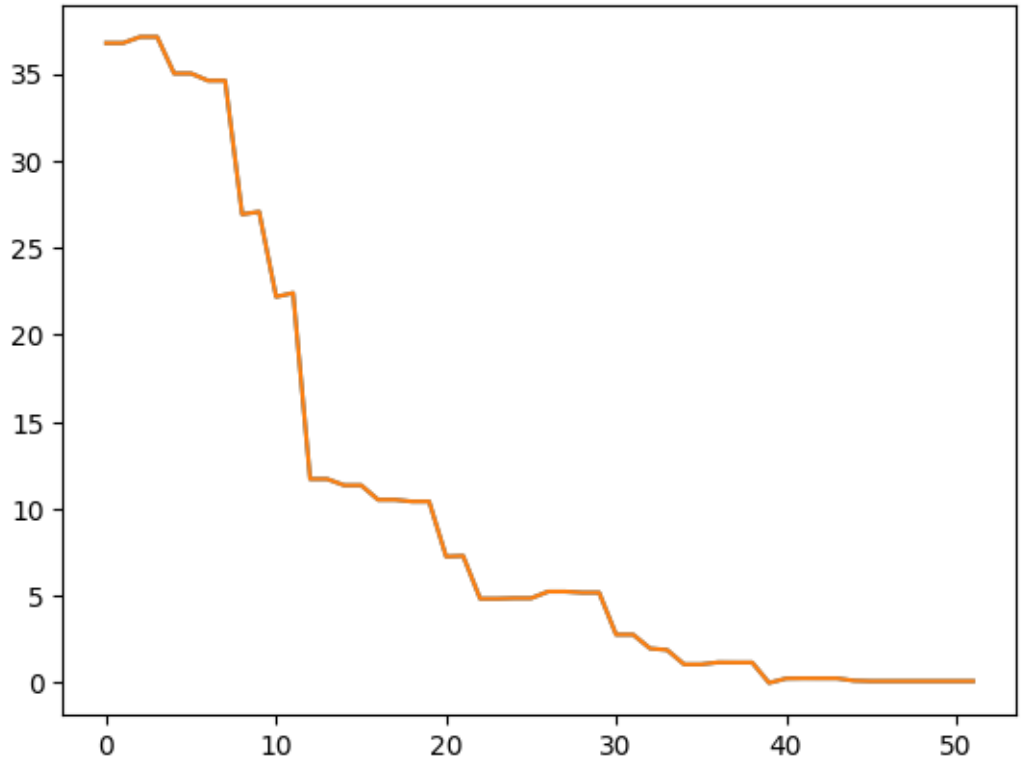
```
print(eigs_2[0])
eigs_2 = match_eigenvalues(self.eigs_0, eigs_2)
print(eigs_2[0])
sens -= eigs_2
sens = sens / (self.ratings[gen_i] * 2 * dP)


powers = self._change_power_with_distributed_slack(change, gen_i)
change_all_gen_powers(self.ps, powers)



plt.plot(eigs_2)
plt.show()
```

```
(-35.72412135928444+10.08104988840602j)
(-35.47082355996548+9.679235693390309j)
(-35.47056979676003+9.67901261909162j)
(-35.47056979676003+9.67901261909162j)
```



[ ]:

[22]:
```
sens_single_gen, eigs_1, eigs_2 =senser.get_gen_sens_single_gen(0, dP=1e-5,␣
↪return_eigs=True)

plt.plot(abs(eigs_1))
plt.plot(abs(eigs_2))
plt.show()

# This value of dP gives varying ordering of eigenvalues! Must do some kind of␣
↪sorting.
```



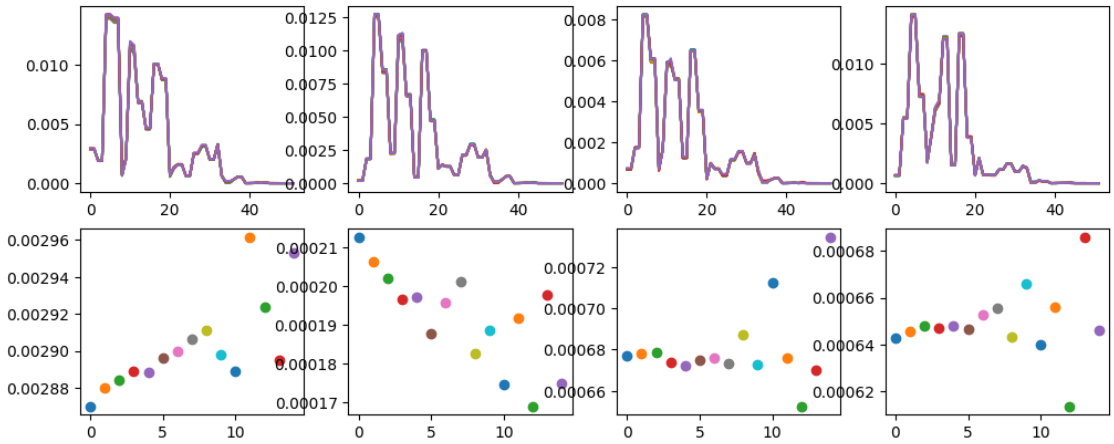
[23]:
```
# From https://stackoverflow.com/questions/54183370/
↪how-to-sort-vector-to-have-minimal-distance-to-another-vector-efficiently
import numpy as np
from scipy import optimize

def match_eigenvalues(v1, v2, dist, return_idx=False):
    assert v1.ndim == v2.ndim == 1
    assert v1.shape[0] == v2.shape[0]
    n = v1.shape[0]
    t = np.dtype(dist(v1[0], v2[0]))
    dist_matrix = np.fromiter((dist(x1, x2) for x1 in v1 for x2 in v2),
                              dtype=t, count=n*n).reshape(n, n)
```

```
    row_ind, col_ind = optimize.linear_sum_assignment(dist_matrix)
    return (v2[col_ind], col_ind) if return_idx else v2[col_ind]

eigs_1_sorted, sort_idx = match_eigenvalues(eigs_0, eigs_1,  lambda x1, x2:␣
 ↪abs(x1 - x2), True)

# plt.plot(abs(eigs_0))
# plt.plot(abs(eigs_1_sorted))
# plt.show()

# That works! Now included in GenSensDispatchUnconstrained
```

[24]:
```
np.sum(genser-genser2)
```

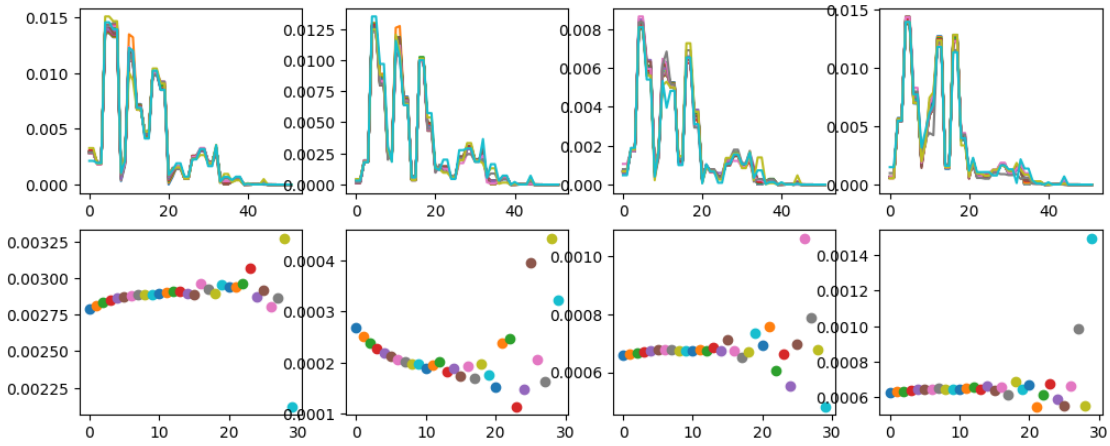
[24]:
```
(4.6067657952339676e-05+0j)
```

[25]:
```
# Check sensitivity to dP
fig, ax = plt.subplots(2, 4)
fig.set_figwidth(12)
for i, dP in enumerate(10.0**(-np.arange(2.5, 4, 0.1))):  # , 3, 4, 5, 6, 7,␣
 ↪8])):
    # print(dP)
    genser_test = abs(senser.get_gen_sens(dP=dP))
    for i_gen, ax_ in enumerate(ax.T):
        ax_[0].plot(genser_test[:, i_gen], label=f'dP')
        ax_[1].scatter(i, genser_test[0, i_gen])
```



[26]:
```
# Check sensitivity to dP
# Slightly wider range makes sensitivity vary more
fig, ax = plt.subplots(2, 4)
fig.set_figwidth(12)
```

```
for i, dP in enumerate(10.0**(-np.arange(2, 5, 0.1))):  # , 3, 4, 5, 6, 7, 8])):
    # print(dP)
    genser_test = abs(senser.get_gen_sens(dP=dP))
    for i_gen, ax_ in enumerate(ax.T):
        ax_[0].plot(genser_test[:, i_gen], label=f'dP')
        ax_[1].scatter(i, genser_test[0, i_gen])
```



[27]:
```
jac = senser._make_jacobian(senser.zeta+0.01)
```

[28]:
```
f = senser._lagrangian_value(senser.zeta+0.01)
```

[29]:
```
jac
```

[29]:
```
array([[-7.55355247e-03,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00, -1.48717442e-04,  1.00000000e+00],
       [ 0.00000000e+00, -7.55355247e-03,  0.00000000e+00,
         0.00000000e+00, -2.24465476e-04,  1.00000000e+00],
       [ 0.00000000e+00,  0.00000000e+00, -7.55355247e-03,
         0.00000000e+00, -1.50548135e-04,  1.00000000e+00],
       [ 0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
        -2.26606574e-02, -3.92726027e-04,  1.00000000e+00],
       [-1.48717442e-04, -2.24465476e-04, -1.50548135e-04,
        -3.92726027e-04,  0.00000000e+00,  0.00000000e+00],
       [ 1.00000000e+00,  1.00000000e+00,  1.00000000e+00,
         1.00000000e+00,  0.00000000e+00,  0.00000000e+00]])
```

[30]:
```
dx=np.linalg.solve(-jac, f)
```

[ ]:
```

```