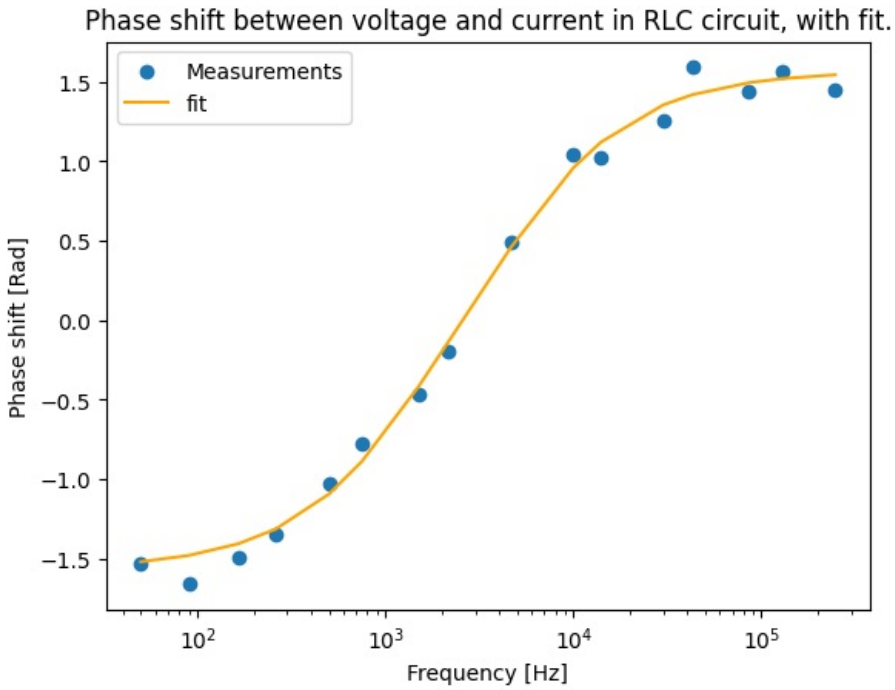
In [3]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import os
from scipy.signal import find_peaks
from scipy import stats
from scipy import optimize
from scipy.optimize import curve_fit
from IPython.display import Image
from IPython.core.display import HTML
from scipy import signal
from scipy.signal import find_peaks
```

In [320…
```
#import all the data

df=pd.read_csv('E11.e.csv')

f_RLC=np.array(df['f(Khz)_RCL'])
T_RLC=np.array(df['T_s(mus)_RCL'])

f_RC=np.array(df['f(Khz)_RC'])
T_RC=np.array(df['T_s(mus)_RC'])

f_RL=np.array(df['f(Khz)_RL'])
T_RL=np.array(df['T_s(mus)_RL'])

C=0.686*1e-6      #Capacitor from [picoF] to [F]
L=6.11*1e-6            #Coil with inductance in [H]
R=270.3            #Resistor in [Ohm]

f_RLC= f_RLC[:-3]
T_RLC= T_RLC[:-3]

T_RLC=T_RLC*1e-6  #in [s]
T_RC=T_RC*1e-6  #in [s]
T_RL=T_RL*1e-6  #in [s]

f_RLC=f_RLC*1000 #in [Hz]
f_RC=f_RC*1000 #in [Hz]
f_RL=f_RL*1000 #in [Hz]
```

RLC

In [322…
```
#phase shift for RLC

ps_RLC=2*np.pi*f_RLC*T_RLC


# Φ = arctan ((2pifL - 1 / 2pifC) / R)

#fit by phase shift in RLC circuit:

def phase_fit(f,c,l,r):
    return np.arctan(((2*np.pi*f*l)-1/(2*np.pi*f*c))/r)

popt, pcov = curve_fit(phase_fit,f_RLC,ps_RLC, p0 = [0.686*1e-6,6.11*1e-6,270.3])

plt.scatter(f_RLC,ps_RLC, label="Measurements")
plt.plot(f_RLC,phase_fit(f_RLC, popt[0],popt[1],popt[2]),label = "fit", color="orange")
plt.xlabel("Frequency [Hz]")
plt.ylabel("Phase shift [Rad]")
plt.xscale("log")
plt.title("Phase shift between voltage and current in RLC circuit, with fit.")
plt.legend()
plt.show()
```




```
2.045964757258123e-06 0.0018704639059924232 76.95986102006198
```

In [335…

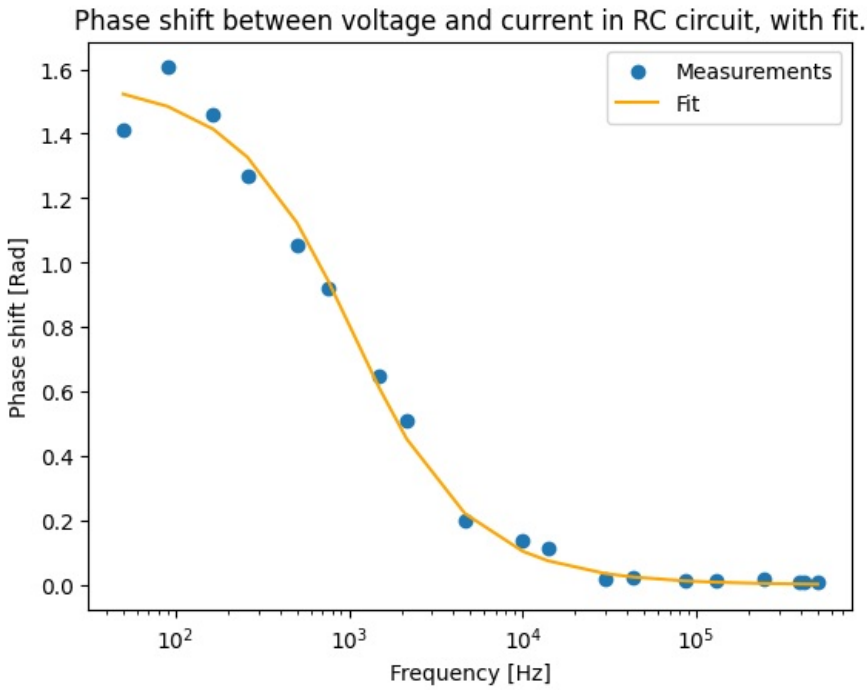
```
f_r=50000#Hz
C=0.686*1e-6 #F

L=1/((2*np.pi*f_r)**2*C) #Henry
print(L)
```

```
1.4769851842906384e-05
```

RC

In [259…

```
#phase shift for RC

ps_RC=np.abs(2*np.pi*f_RC*T_RC)

# Φ = arctan(1 / (2piRC))

#fit by phase shift in RLC circuit:

def phase_fit(f,c,r):
    return np.arctan(1/(2*np.pi*f*c*r))

popt, pcov = curve_fit(phase_fit,f_RC,ps_RC, p0 = [0.668*1e-6,270.3])

plt.scatter(f_RC,ps_RC, label="Measurements")
plt.plot(f_RC,phase_fit(f_RC, popt[0],popt[1]),label = "Fit", color="orange")
plt.xlabel("Frequency [Hz]")
plt.ylabel("Phase shift [Rad]")
plt.xscale('log')
plt.title("Phase shift between voltage and current in RC circuit, with fit.")
plt.legend()
plt.show()

print(popt[0],popt[1])
```

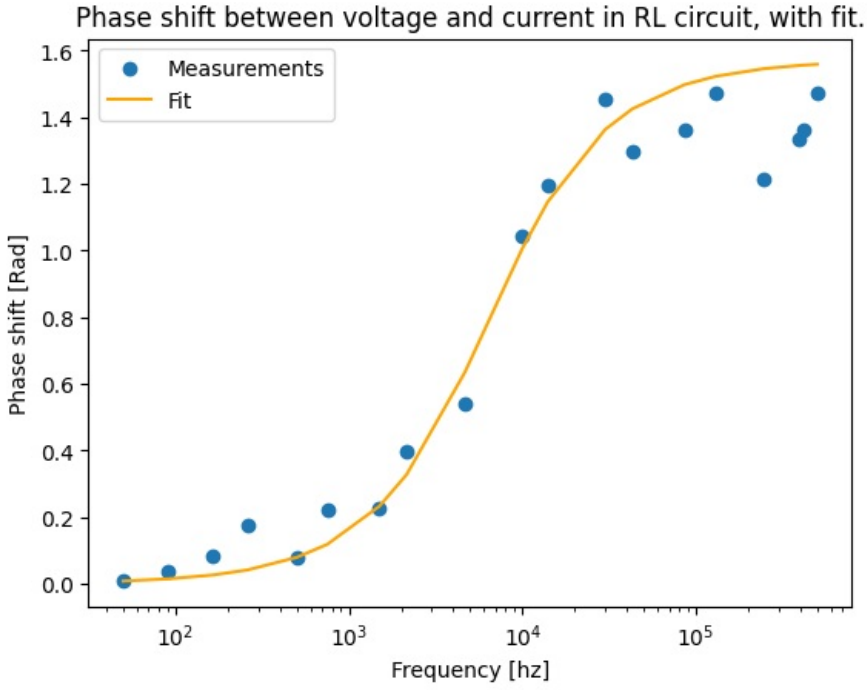



```
5.831534598285514e-07 261.33700514647705
```

RL

In [299…

```
#phase shift for RL

ps_RL=np.abs(2*np.pi*f_RL*T_RL)

# Φ = arctan(2pifL / R)

#fit by phase shift in RLC circuit:

def phase_fit(f,l,r):
    return np.arctan(2*np.pi*f*l/r)

popt, pcov = curve_fit(phase_fit,f_RL,ps_RL, p0 = [6.11*1e-6,270.3])

plt.scatter(f_RL,ps_RL, label="Measurements")
plt.plot(f_RL,phase_fit(f_RL, popt[0],popt[1]),label = "Fit", color="orange")
plt.xlabel("Frequency [hz]")
plt.ylabel("Phase shift [Rad]")
plt.xscale('log')
plt.title("Phase shift between voltage and current in RL circuit, with fit.")
plt.legend()
plt.show()

print(popt[0],popt[1])
```

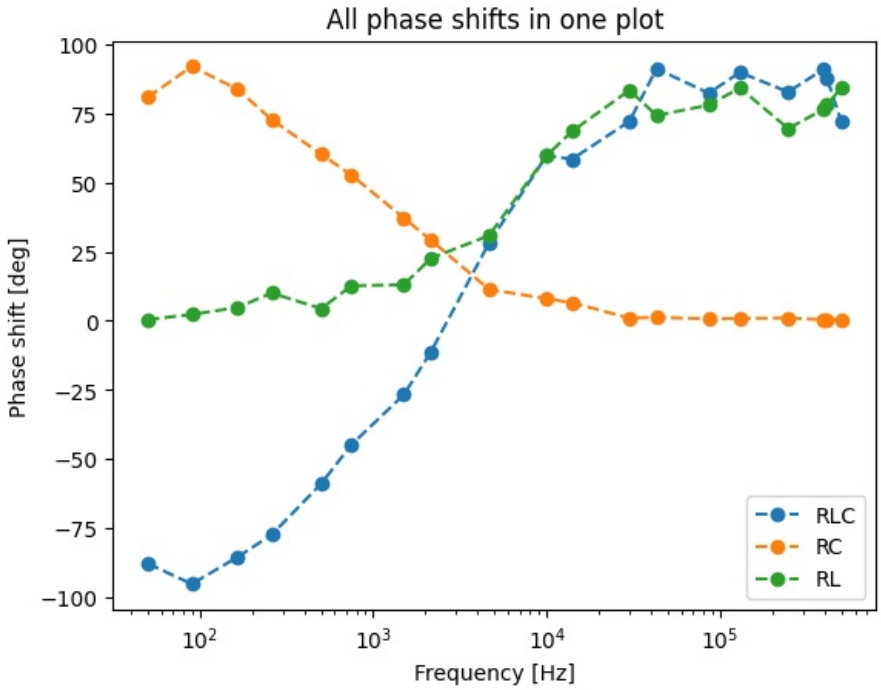


```
8.914593869992357e-05 3.5471759516257406
```

In [248…

```
plt.plot(f_RLC,ps_RLC*(180/np.pi), 'o--', label='RLC')
plt.plot(f_RC,ps_RC*(180/np.pi), 'o--', label='RC')
plt.plot(f_RL,ps_RL*(180/np.pi), 'o--', label='RL')
plt.xlabel("Frequency [Hz]")
plt.ylabel("Phase shift [deg]")
plt.xscale('log')
plt.title("All phase shifts in one plot")
plt.legend()
plt.show
```

Out[248]: <function matplotlib.pyplot.show(close=None, block=None)>



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