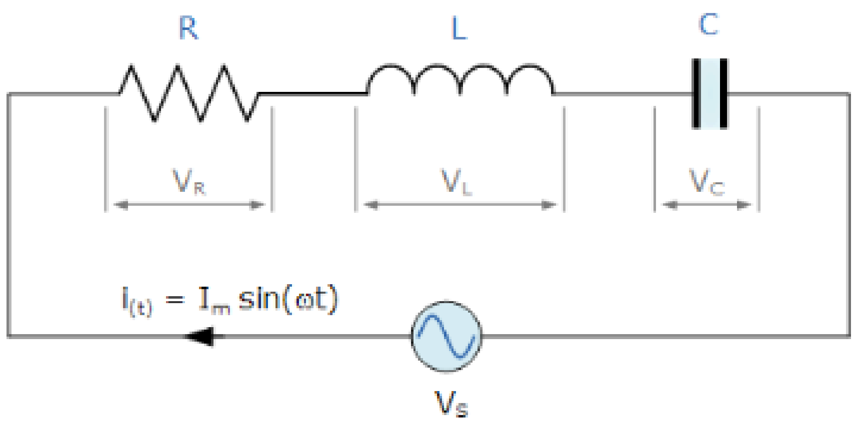
STUDY OF LCR SERIES CIRCUIT USING expEYES-17

ExpEYES ... Your Lab@Home
Low Cost Science Experiments using Computers
ExpEyes

INDEX

- LCR SERIES CIRCUIT
- RESONANT LCR SERIES CIRCUIT
- EXPEYES
- CODING IN EXPEYES
- PYTHON CODE
- OBSERVATION
- RESULTS AND CONCLUSSION

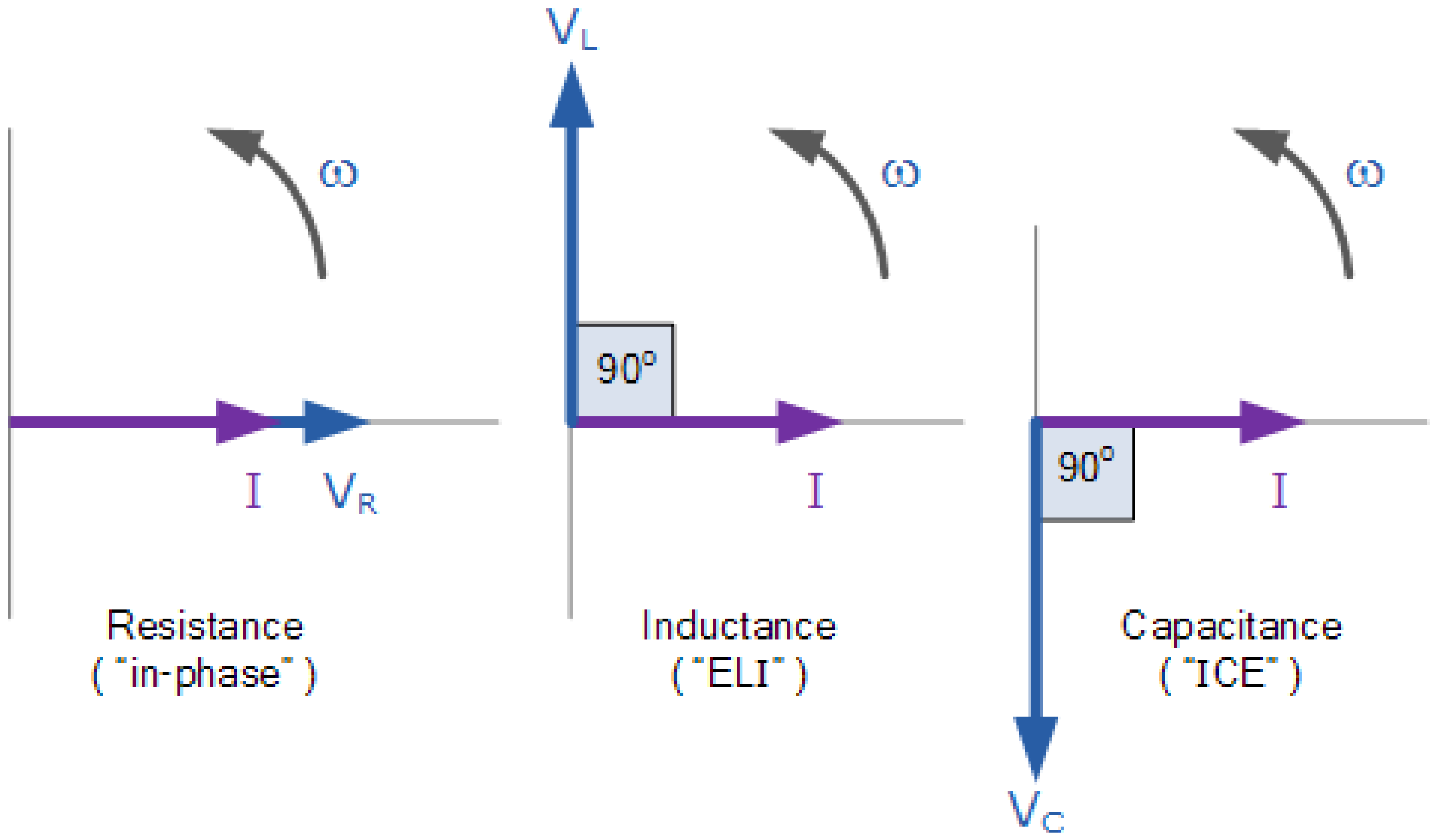
LCR SERIES CIRCUIT



- L,C,R IN SERIES
- used to select a certain narrow range of frequencies from the total spectrum
- eg:AM/FM radio tuners use a RLC circuit to tune a radio frequency.

VOLTAGE ACROSS R,L,C

- voltage across a pure resistor, VR is “in-phase” with current
- voltage across a pure inductor, VL “leads” the current by 90*
- voltage across a pure capacitor, VC “lags” the current by 90*
- VL and VC are 180* “out-of-phase” and in opposition to each other



V_L
ω
ω
ω
90°
90°
I
V_R
I
I
Resistance
("in-phase")
Inductance
("ELI")
Capacitance
("ICE")
V_C

PHASOR DIAGRAM

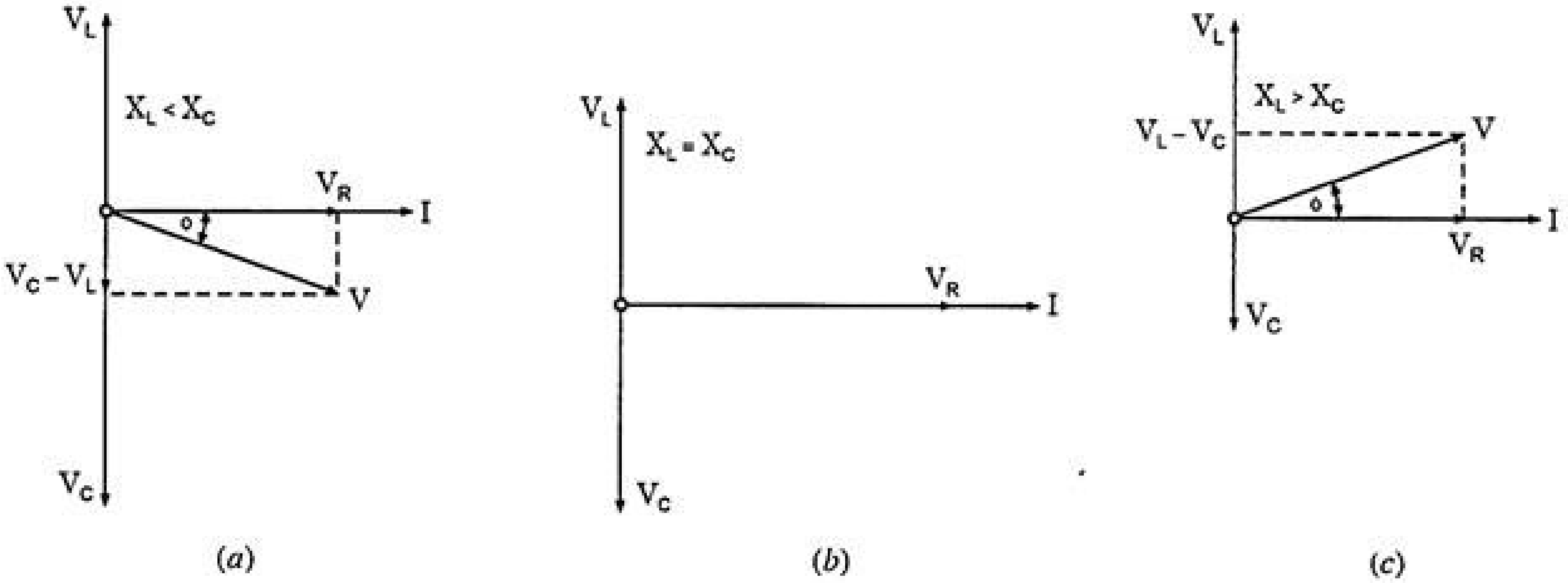
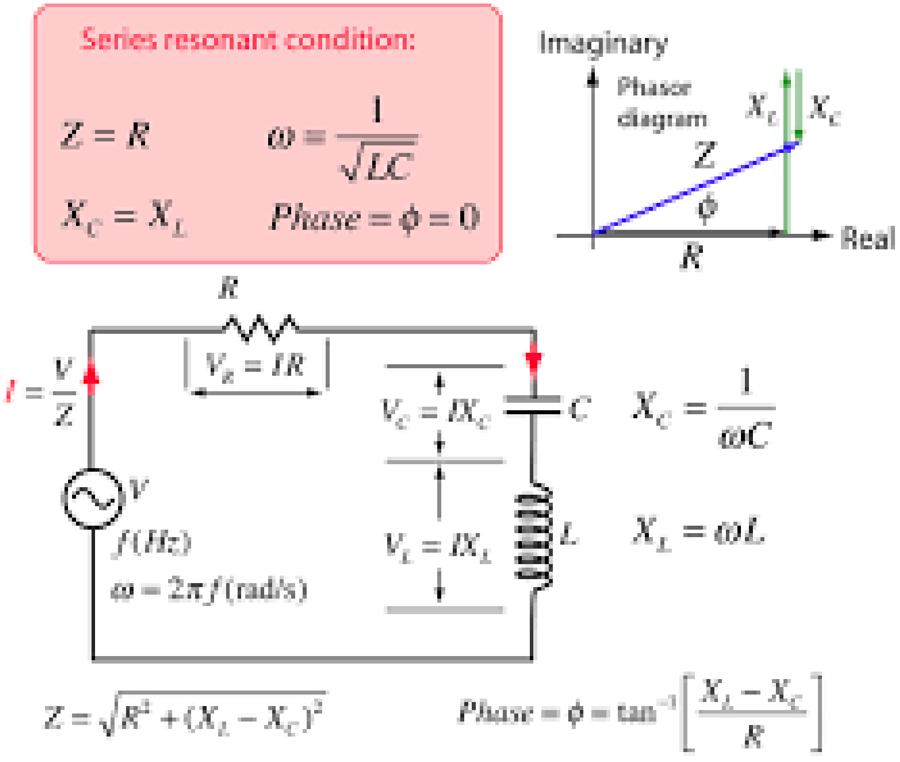


Fig. 6.2

PHASE IN LCR SERIES



- At resonance Φ=0
- Φ is +ve when circuit is inductive
- Φ is -ve if circuit is capacitive
- Φ=0 ,pure resistive

IMPEDENCE

$$I_{rms} = \frac{V_{rms}}{Z} \to Z = \frac{V}{I} \to$$

$$Z = \frac{\sqrt{V_R^2 + (V_L - V_C)^2}}{I} \to$$

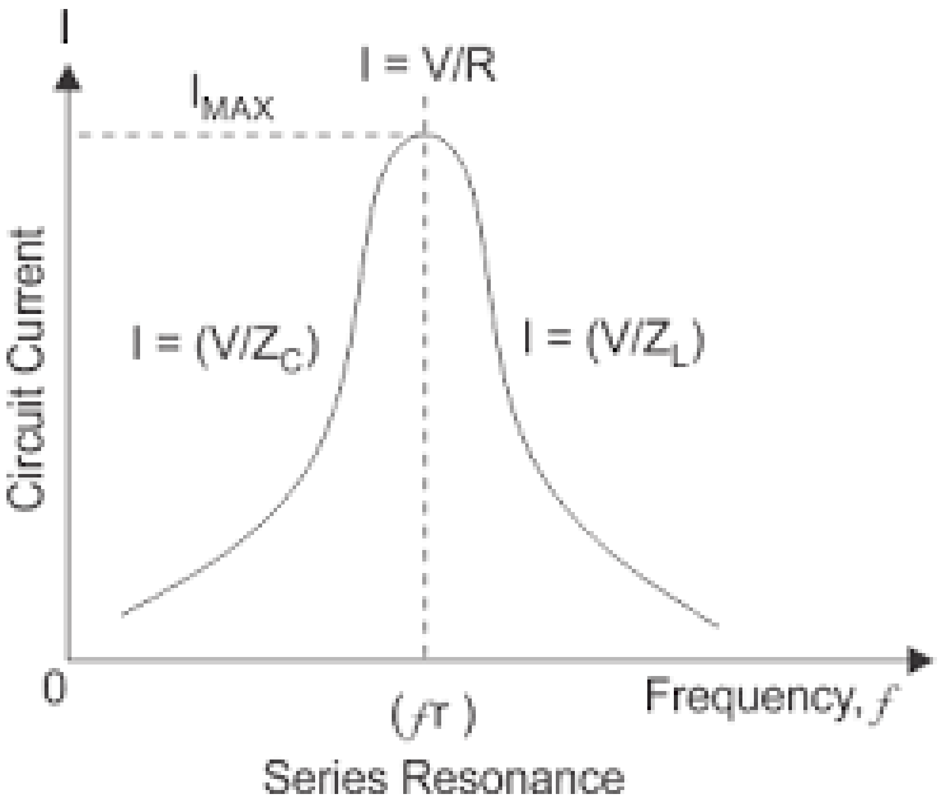
$$Z = \frac{\sqrt{(IR)^2 + (I \times X_L - I \times X_C)^2}}{I} \to$$

$$Z = \frac{I\sqrt{R^2 + (X_L - X_C)^2}}{I} \to$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

- Total resistance offered by circuit
- At resonance Z=R

RESONANT LCR SERIES CIRCUIT



- At resonance $X_L = X_C$
- $Z = R$
- Max current flow through R

RESONANCE FREQUENCY

$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

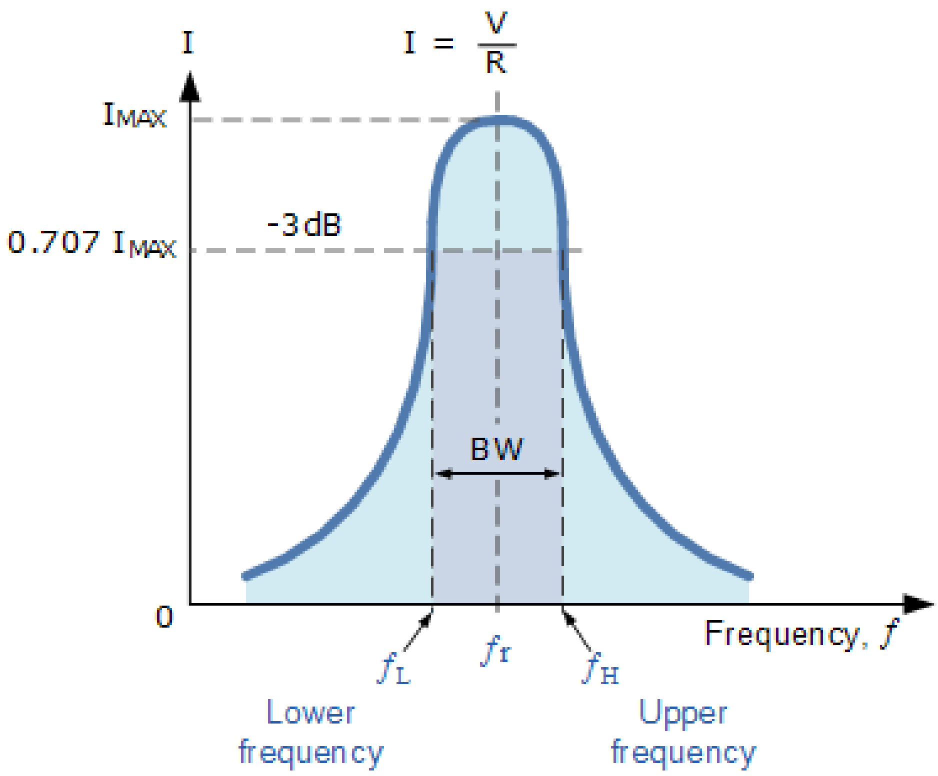
$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore \; f_r = \frac{1}{2\pi\sqrt{LC}}\,(\text{Hz}) \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}}\,(\text{rads})$$

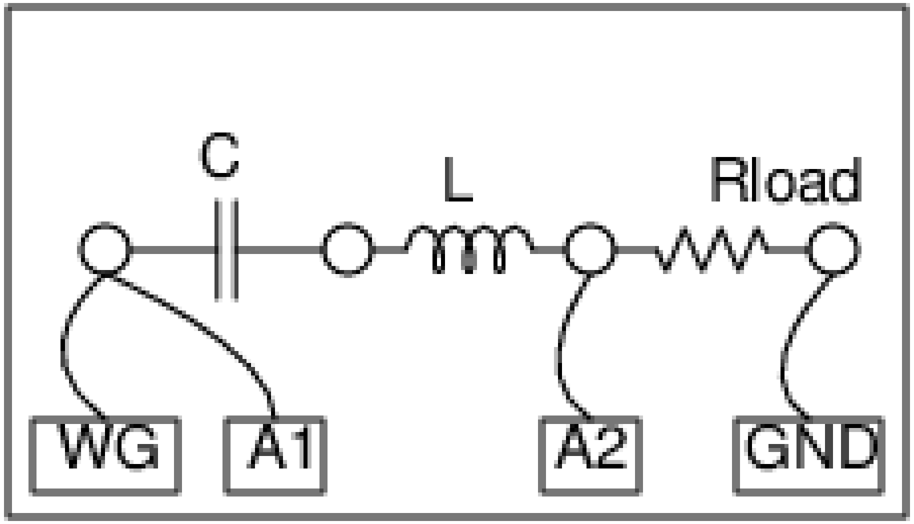
- Only depend on L&C
- Independent of R
- Max current at Fr

QUALITY FACTOR



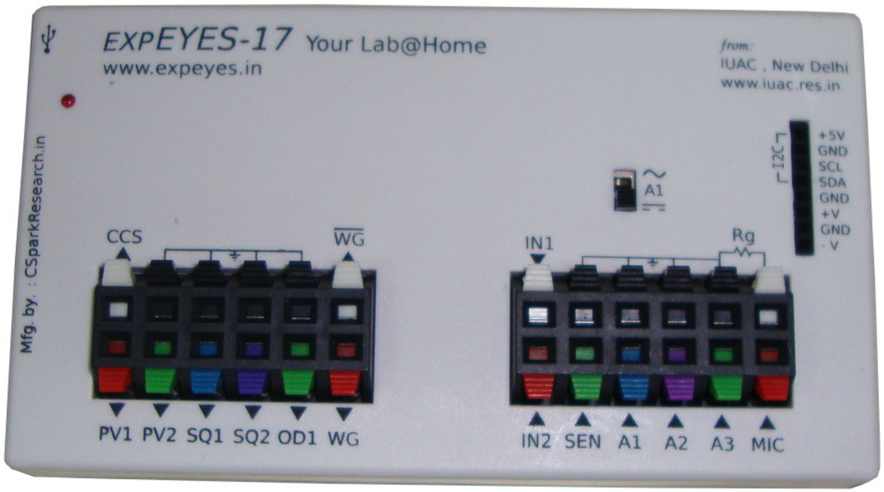
- V_L/V_R Or V_C/V_R
- $Q=X_L/R$ or X_c/R
- Voltage magnification ratio
- Define sharpness

EXPERIMENTAL METHODE



- LCR CIRCUIT CONNECTED TO expEYES
- RUN THE PROGRAM
- GIVE VALUES L,C,R
- GRAPH & FINAL VALUES ARE APPEARED

expEYES-17



- Programmable Voltage sources
- 4-channel oscilloscpe
- Wave genarator
- Constant current source
- Python programmable

CODING expEYES IN PYTHON

- To establish connection

  import eyes17.eyes

  p = eyes17.eyes.open()
- p.set_pv1(v), set_pv2(v) ,to set voltage at pv
- p.get_voltage(input)

#PROGRAMME FOR FREQUENCY RESPONCE OF LCR SERIES CIRCUIT

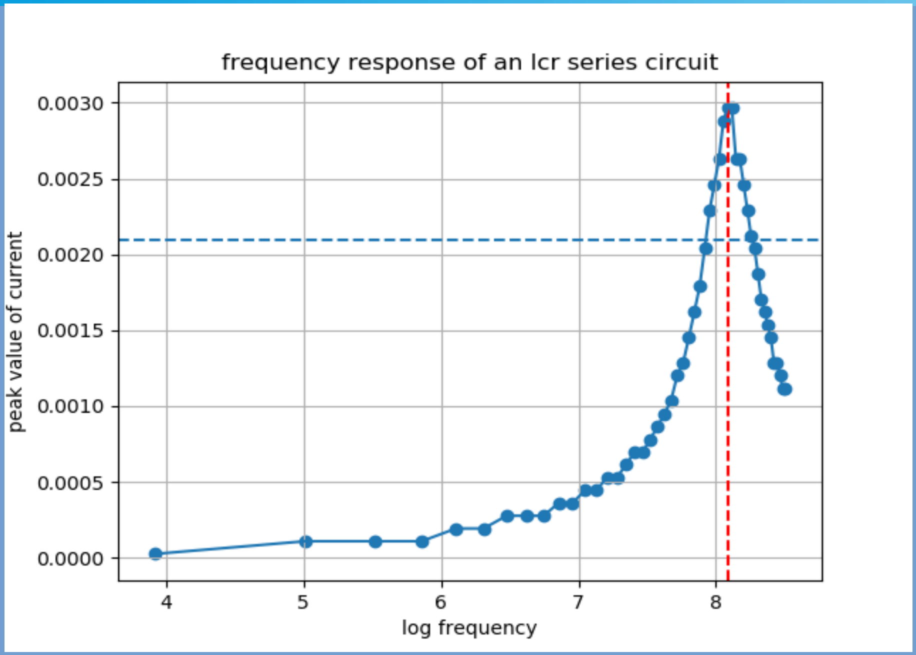
```
 import math
import eyes17.eyes
p=eyes17.eyes.open()
from math import*
from pylab import*
R=input("Enter the value of Resistance in ohms =")
C=input("enter the value of capacitance in uF =")
C=C*1e-6
 L=input ("enter the value of inductor in mH  =")
 L=L*1e-3
 p.set_sine_amp(2)
 v0lis=[]
 i0lis=[]
 freqlis=[]
 freqlog=[]
 for f in range(50,5000,50):
        p.set_sine(f)
        time.sleep(.01)
        freqlis.append(f)
        logf=log(f)
        frqlog.append(logf)
        t,v=p.capture1('A2',300,300)
        v0=max(v)
        v0lis.append(v0)
         i0=v0/R
         i0lis.append(i0)
    freqlis=list(freqlis)
    i0lis=list(i0lis)

    Ir=max(i0lis)
    k=i0lis.index(Ir)
   frex=freqlis[k]
   frexl=log(frex)

  Icut=Ir/sqrt(2)
  frth=1/(2.0*pi*sqrt(L*C))
  Q=(frth*2.0*pi*L)/R
  print"theoretical value of resonance frequency is=",frth
  print"the quality factor is=",Q
  print"experimant value of resonant frequency=",frex
  grid()
  title("frequency response of an lcr series circuit")
  xlabel("log frequency")
  ylabel("peak value of current")
  axvline(x=frexl, linestyle='--' ,color='r')
  axhline(y=Icut, linestyle='--')

  plot(freqlog,i0lis)
  scatter(freqlog,i0lis)
  show()
```

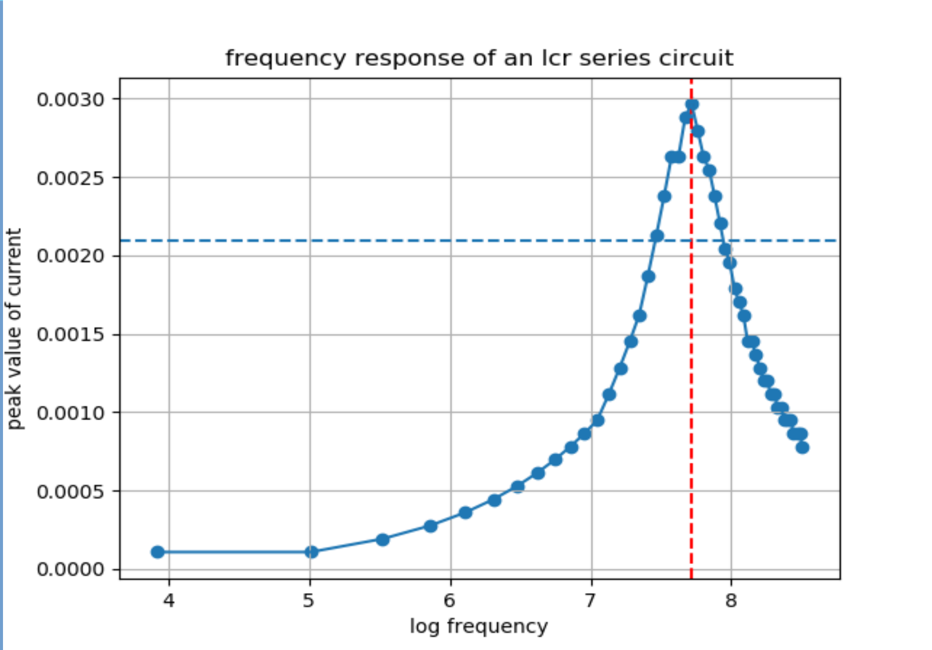
OBSERVATIONS

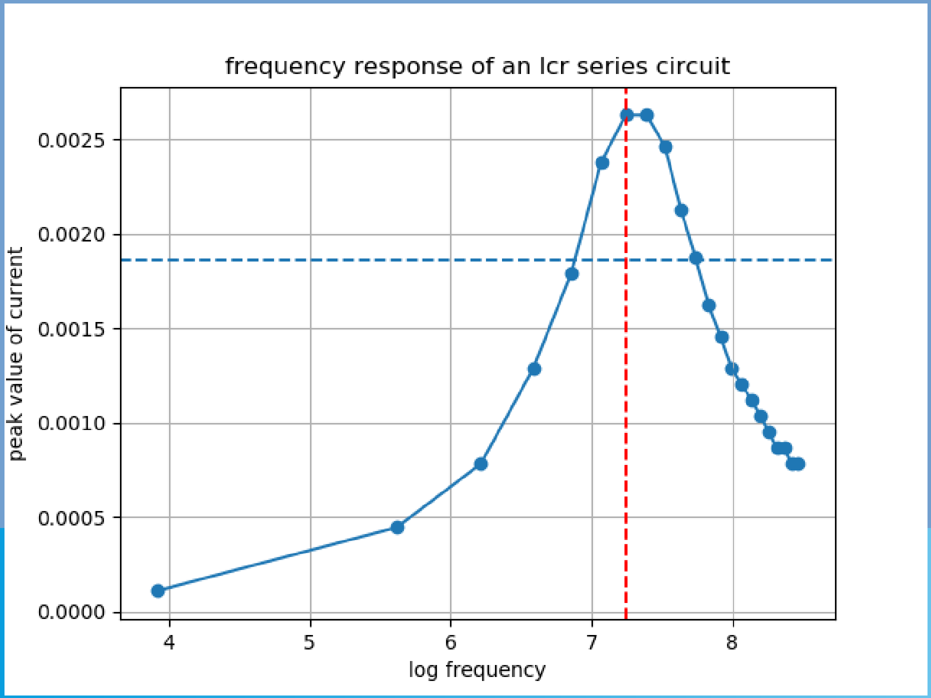
NO;	L IN Mh	C IN Uf	R IN ohm	Q-TH	Q-PR	Fr-TH	Fr-PR	F 1	F 2	BW IN Hz	ERROR
1	84.75	0.032	384	4.23802622601	4.215624642	3056.154383	3040	2453.45	3919.15	1465.7	0.53%
2	109	0.032	384	4.80625750659	4.6371216564	2694.83322696	2600	1992.41	3451.72	1459.31	3.52%
3	118	0.032	384	5.0007459296	4.8655416223	2590.02608979	2520	1951	3303.57	1352.57	2.70%
4	119	0.032	384	5.021890827	4.8094183785	2579.12066835	2470	1957.75	3285.95	1328.2	4.23%
5	120	0.032	384	5.04294706537	4.8105637508	2568.3518502	2450	1955.1	3274.26	1319.16	4.61%
6	137	0.032	384	5.38832856681	5.17818375	2403.7254346	2310	1802.573	2936.636	1134.063	3.90%
7	155	0.032	384	5.73138569715	5.452790374	2259.8483352	2150	1681.447	2778.788	1097.341	4.86%
8	187	0.032	384	6.29527330918	6.0277672795	2057.42654687	1970	1539.634	2491.699	952.065	4.25%
9	155	0.01513	384	8.3351834	8.24259	3286.50894419	3250	2872.1	3879.38	1007.28	1.11%
10	155	0.0265	384	6.2981309725	6.1629212134	2483.312334	2430	1913	3057.15	1133.31	2.15%
11	155	0.0316	384	5.7675462	5.7064085309	2274.106194	2250	1736.5	2815.96	1138.21	1.06%
12	155	0.0587	384	4.23170684631	4.0325286952	1668.534657	1590	1123.82	2290.92	1146.68	4.71%
13	155	0.0644	384	4.0400960575	4.0071668795	1592.983762	1580	1097.39	2268.27	1170.88	0.82%
14	155	0.0771	384	3.69238889	3.550654197	1455.8850738	1400	972.47	2311.42	1338.95	3.84%
15	155	0.1163	384	3.00638618687	2.8658851733	1185.39864151	1130	698.39	2039.43	1341.04	4.67%
16	155	0.1457	384	2.6859928	2.561543385	1059.06961	1010	605.38	2089.64	1484.26	4.63%
17	109	0.2086	137.8	5.24574142468	5.0793488886	1055.479324	1044	677.35	1722.36	1045.01	1.09%
18	109	0.2086	140.6	5.14127431238	4.9781954256	1055.47932	1044	673.08	1718.21	1045.13	1.09%
19	109	0.2086	162.1	4.45936562	4.4108658557	1055.4793249	1044	670.86	1719.28	1048.42	1.09%
20	109	0.2086	172.4	4.1929418116	4.147339647	1055.47932	1044	668.8	1722.48	1053.68	1.09%
21	109	0.2086	187.5	3.86144854872	3.92920604	1055.47932	1044	646.11	1702.12	1056.01	1.09%
22	109	0.2086	197.4	3.6619208121	3.7261771589	1055.479324	1044	643.55	1737.7	1094.15	1.09%
23	109	0.2086	202.2	3.5749909412	3.53610957	1055.4793249	1044	635.15	1759.33	1124.18	1.09%
24	109	0.2086	218.7	3.30527283183	3.3632710159	1055.47932	1044	641.41	1804.64	1163.23	1.09%

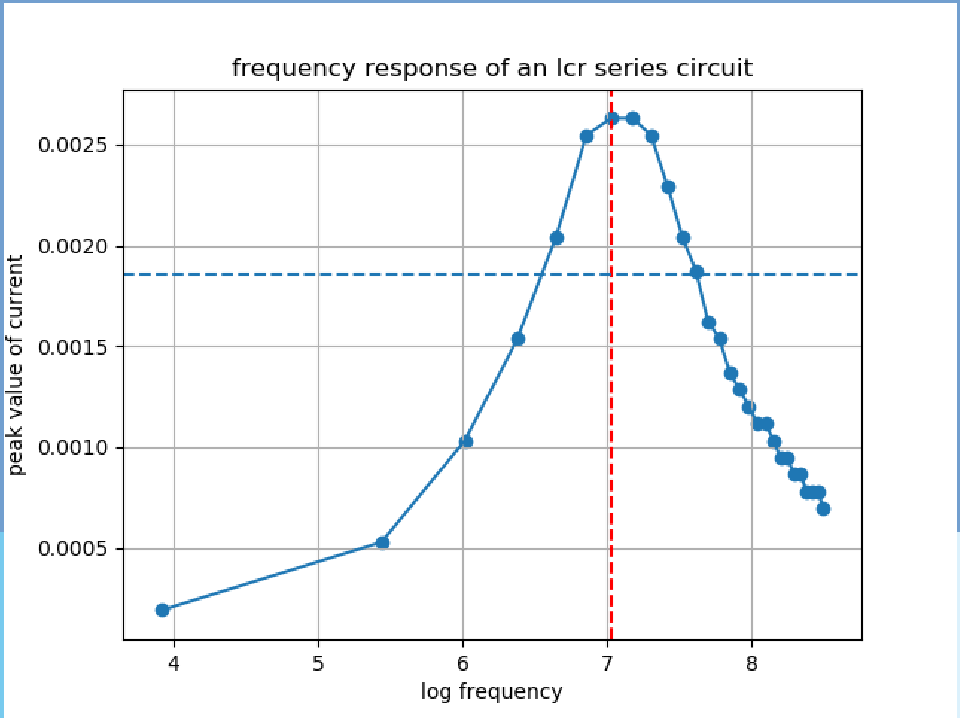
Changing capacitance

15.13nF, 31.6nF ,77.1nF ,116.3nF



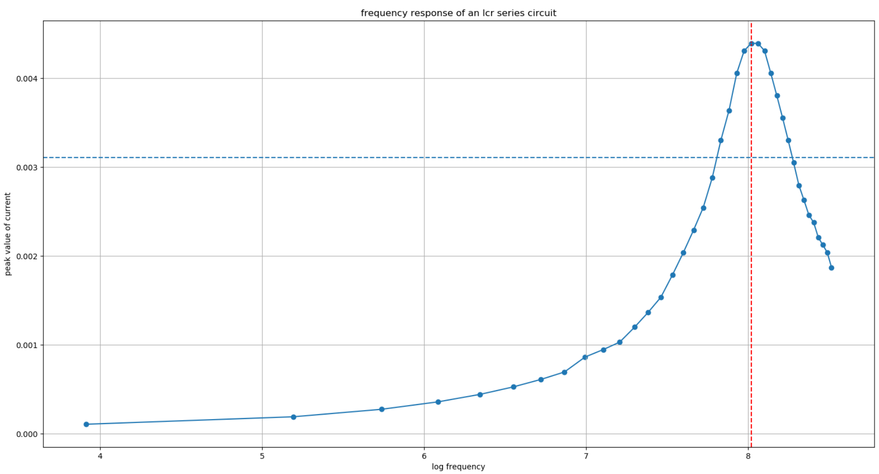


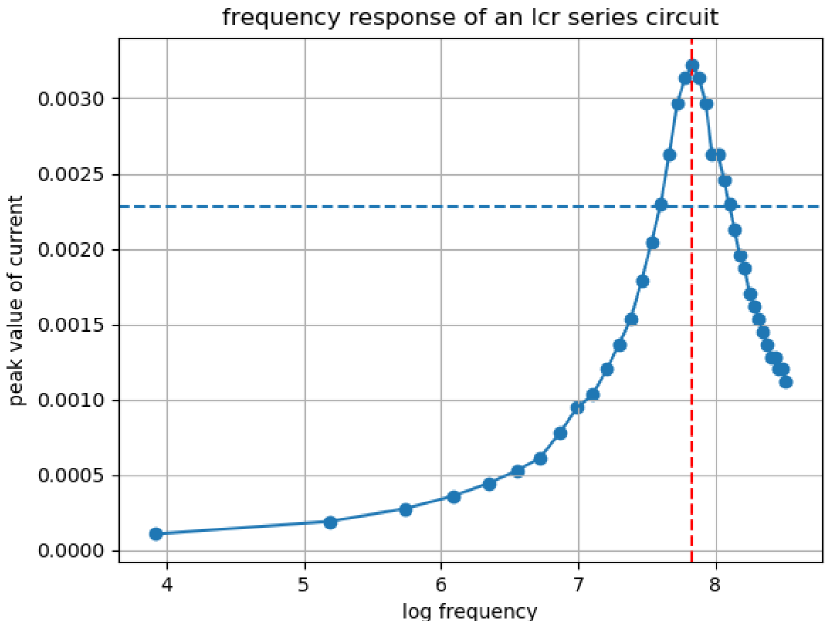


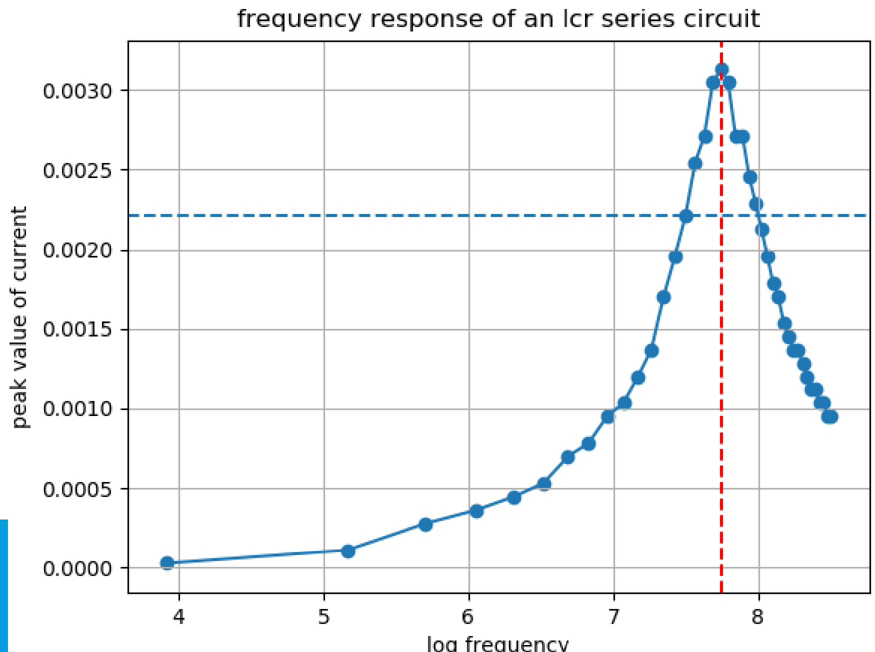


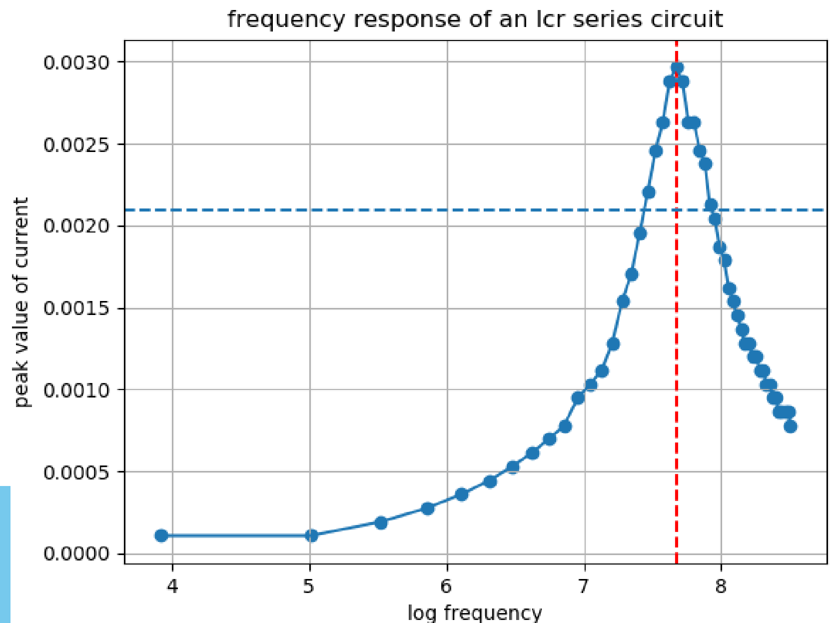
Changing inductance

87.5mH,118mH,137mH,155mH



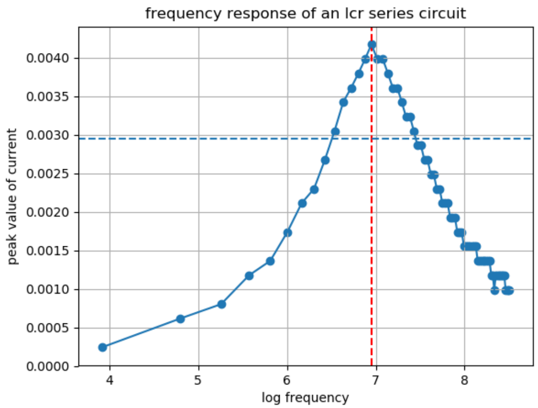


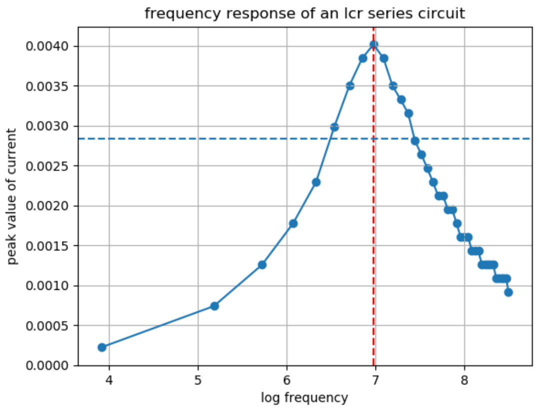


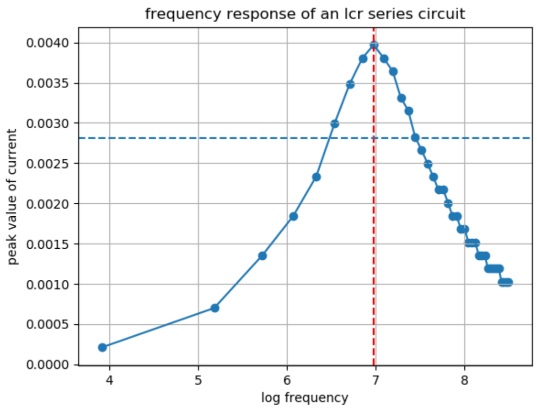


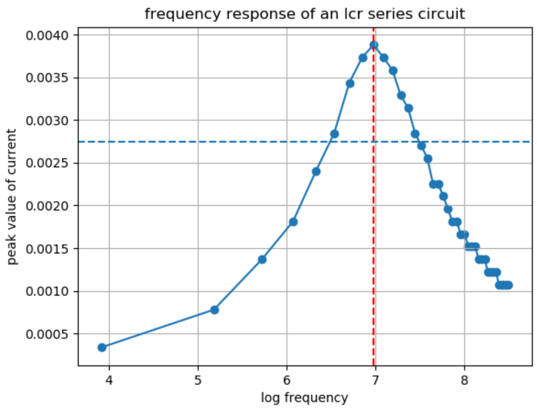
Changing resistance

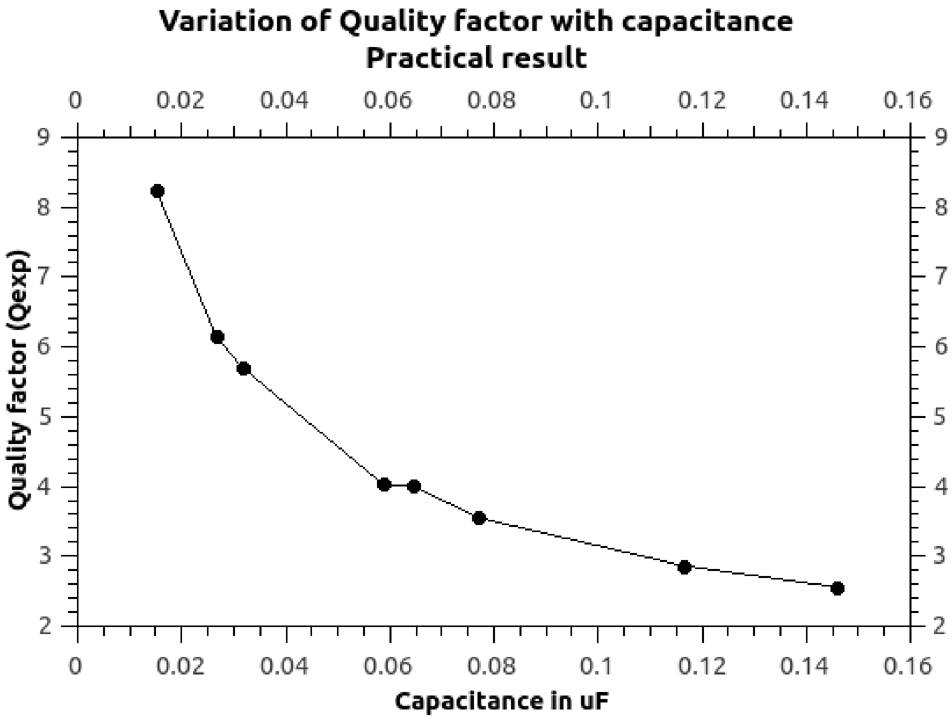
172,187,197,218 ohm

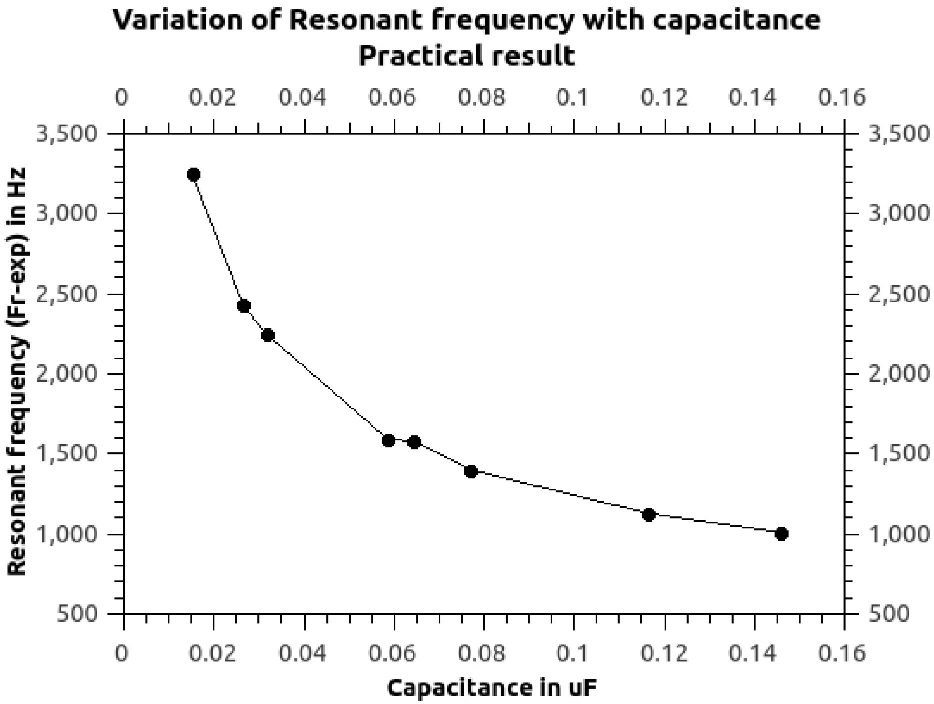


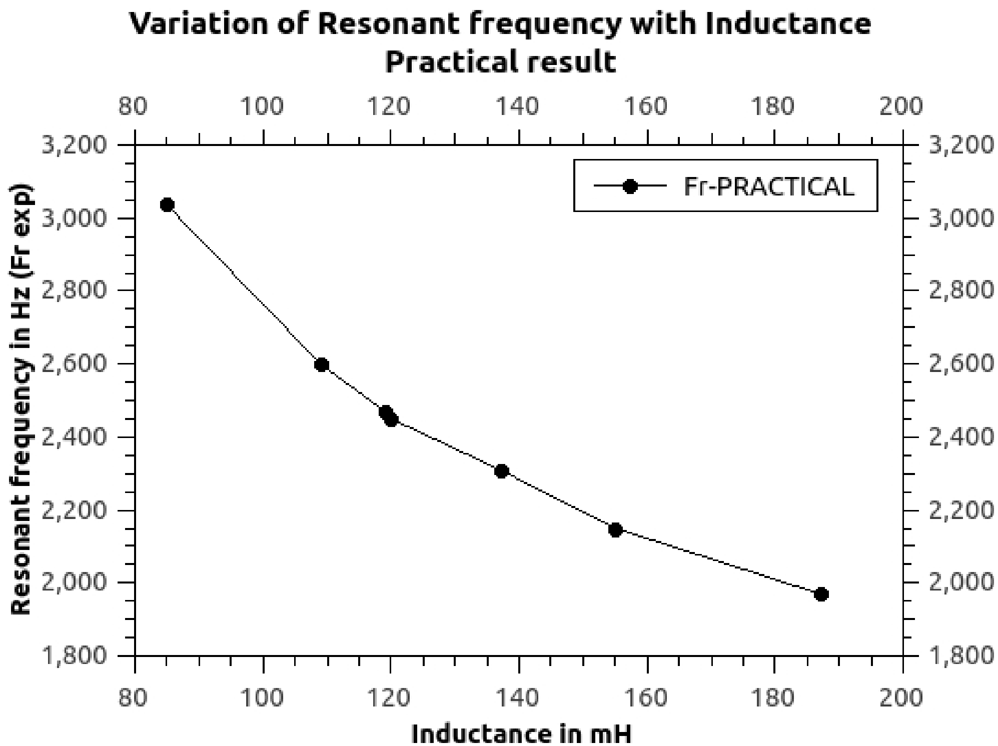


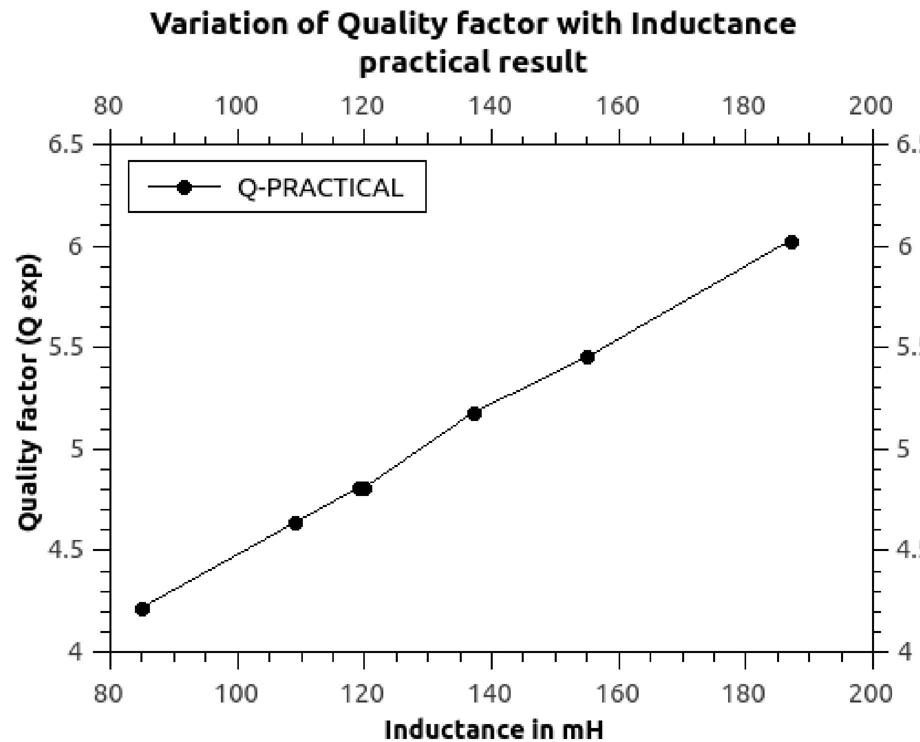


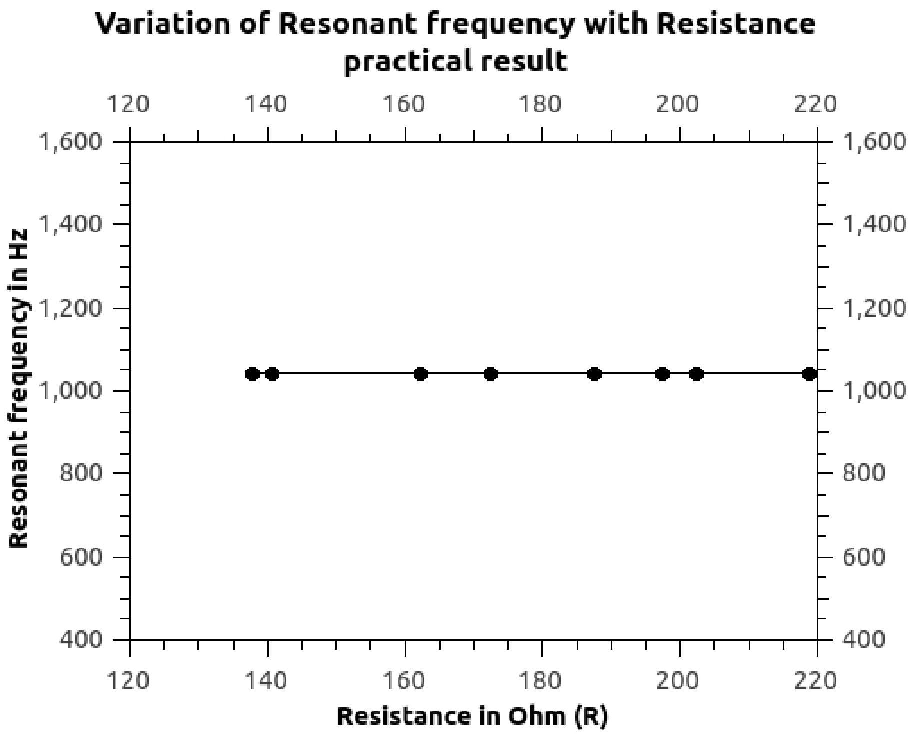


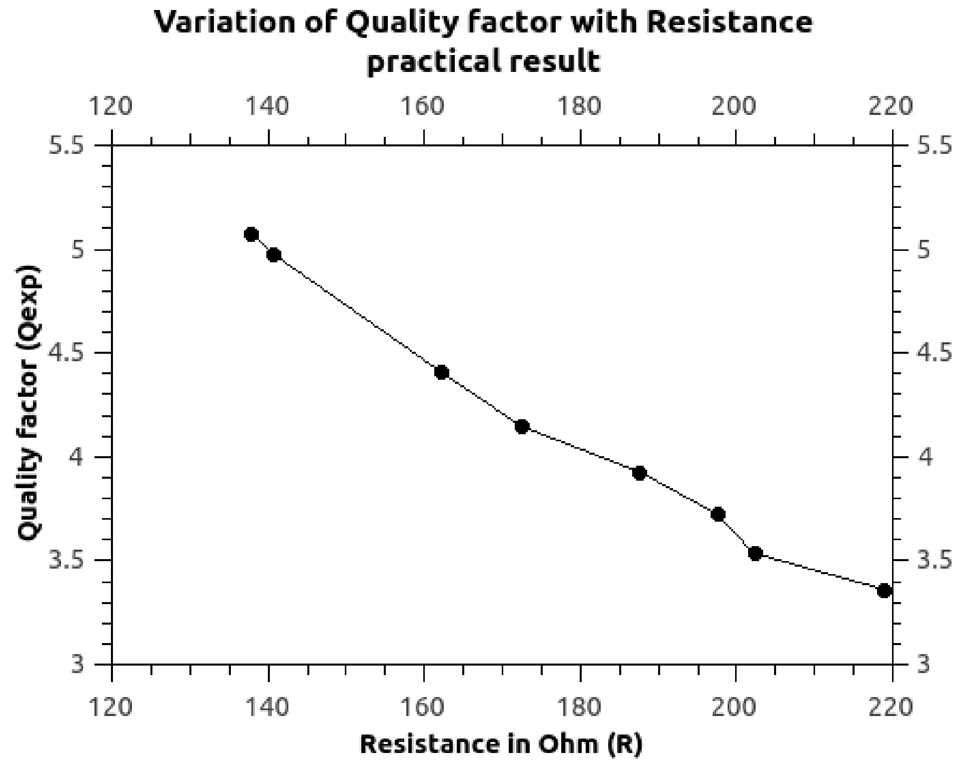

Variation of Quality factor with capacitance
Practical result
Quality factor (Qexp)
Capacitance in uF
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
2
3
4
5
6
7
8
9


Variation of Resonant frequency with capacitance
Practical result
Resonant frequency (Fr-exp) in Hz
Capacitance in uF
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
500
1,000
1,500
2,000
2,500
3,000
3,500


Variation of Resonant frequency with Inductance
Practical result
Fr-PRACTICAL
Resonant frequency in Hz (Fr exp)
Inductance in mH
80
100
120
140
160
180
200
1,800
2,000
2,200
2,400
2,600
2,800
3,000
3,200


Variation of Quality factor with Inductance
practical result
Q-PRACTICAL
Quality factor (Q exp)
Inductance in mH
80
100
120
140
160
180
200
4
4.5
5
5.5
6
6.5


Variation of Resonant frequency with Resistance practical result
Resonant frequency in Hz
Resistance in Ohm (R)
1,600
1,400
1,200
1,000
800
600
400
120
140
160
180
200
220


Variation of Quality factor with Resistance practical result
Quality factor (Qexp)
Resistance in Ohm (R)
5.5
5
4.5
4
3.5
3
120
140
160
180
200
220

RESULTS AND CONCLUSION

- Fr decreases as c increases
- Fr decreases as L increases
- Fr does not depend on R
- Q decreases as c increases
- Q increases as L increases
- Q decreases as R increases

THANK YOU