Lab 1

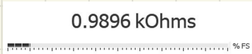
NI ELVIS Workspace Environmett. 0811562 Dept. ECE 何祁恩

Ex1: measure resistor, capacitor,

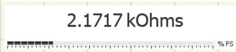
1-5: $R_1 = 0.9896\,k\Omega$ (1.0 kΩ nominal)

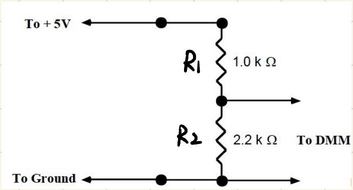
$R_2 = 2.1717\,k\Omega$ (2.2kΩ nominal)

R_1:



R2:



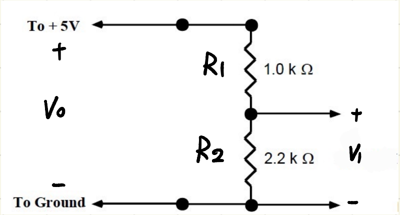


1-6

$C = 0.8780\,\mu F$ (1.0μF nominal)

C:

Ex 2: measure voltage divider circuit



2-7

$V_o = 4.9372\,V$

V_o:

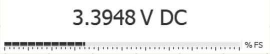
2-8

$$V_1\,(\text{calculated}) = V_o \frac{R_2}{R_1+R_2}$$

$$= 4.9372 \cdot \frac{2.1717}{0.9896+2.1717} \approx 3.3917\,V$$

V_1 (measured) $= 3.3948\,(V)$

V_1



2-9

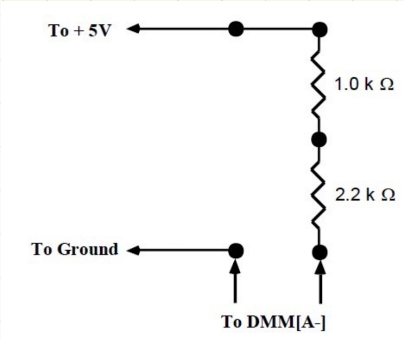
V_1 (measured) $= 3.3948\,V$

V_1 (calculated) $= 3.3917\,V$

$$\text{Error }\% = \frac{3.3948-3.3917}{3.3917} \times 100\% \approx 0.09\%$$

It's almost the same!

Ex 3: measure current

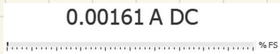


3-4

$$I\text{ (calculated)} = \frac{V_o}{R_1 + R_2}$$

$$= \frac{4.9372}{0.9896k + 2.177k} \approx 1.562\text{mA}$$

I (measured) $= 1.61$mA



3-5

$$\text{Error }\% = \frac{1.61 - 1.562}{1.562} \cdot 100\%$$

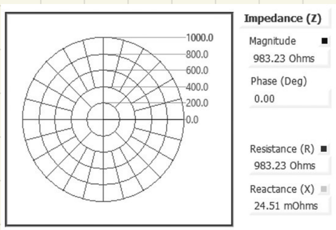
$$\approx 3\%$$

Measure value is quite same as the calculated value!

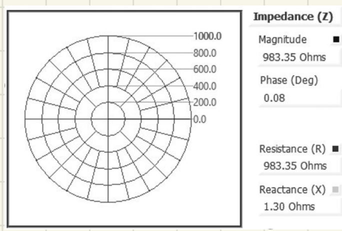
Ex 4: Impedance measurement

4-3 Resistor Impedance

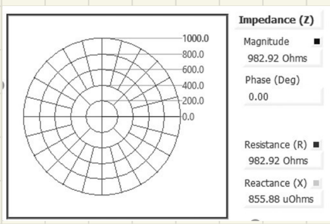
$f = 1$ Hz



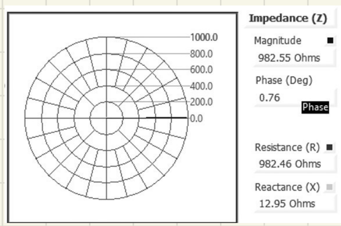
$f = 1000$ Hz



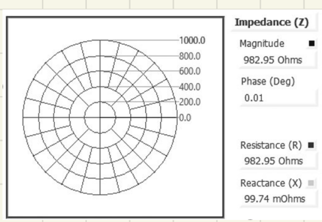
$f = 10$ Hz



$f = 10000$ Hz



$f = 100$ Hz



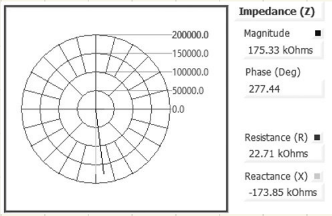
The phasor is along the real axis and the phase is 0.

In high frequency such as: 1kHz, 10kHz, there exist a little non-ignorable reactance value from parasitic capacitance, therefore, the phase of resistor impedance isn't absolute 0 at such cases.

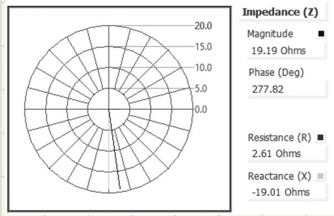
Ex 4: Impedance measurement

4-5 Capacitor Impedance

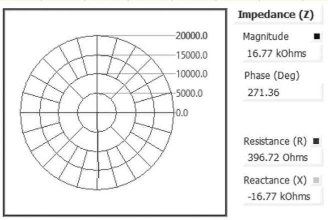
f = 1 Hz



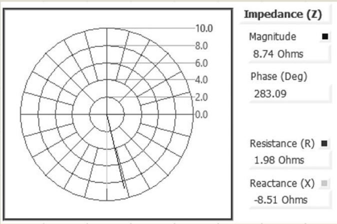
f = 10000 Hz



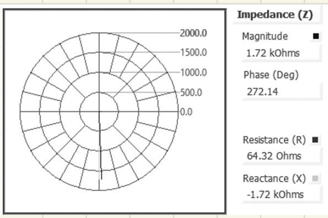
f = 10 Hz



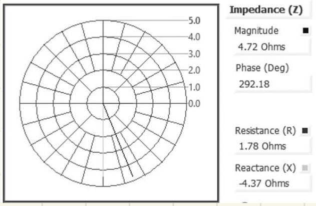
f = 20000 Hz



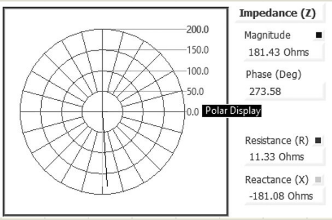
f = 100 Hz



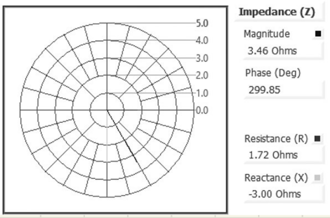
f = 30000 Hz



f = 1000 Hz



f = 35000 Hz



$$X_C = \frac{1}{j\omega C} = -j\frac{1}{\omega C}$$ (phase = 270° or −90°)

(a) $\omega = 2\pi f = 0$

$\Rightarrow X_C \to \infty$ (open circuit)

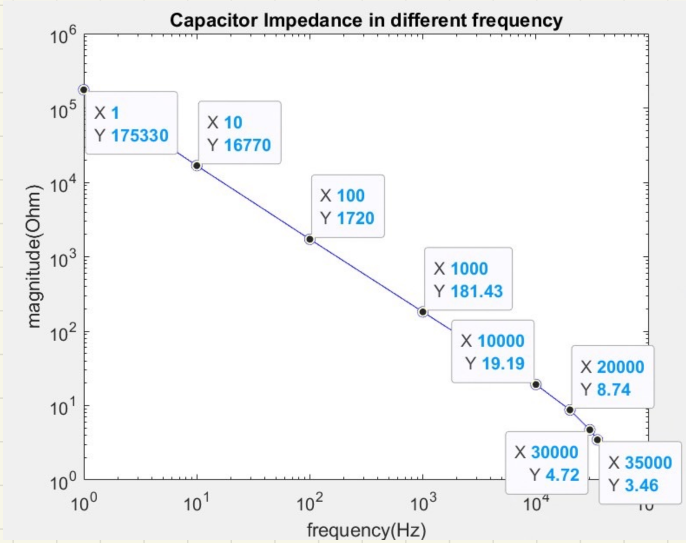
(b) $\omega = 2\pi f = \infty$

$\Rightarrow X_C = 0$ (short circuit)

(c) X_C is inverse proportional to the frequency, as frequency increase, impedance decrease.

4-5 exp

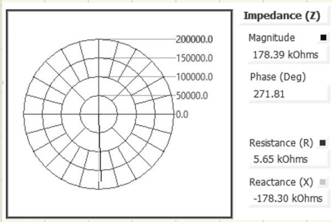
Data visulization both x-y axis are in log scale!



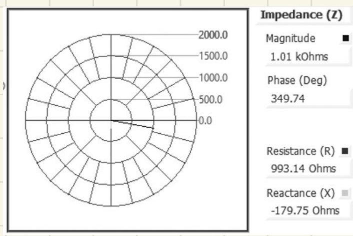
Ex 4: Impedance measurement

4-7,8 RC circuit impedance ($R = 1k\Omega$, $C = 1\mu F$)

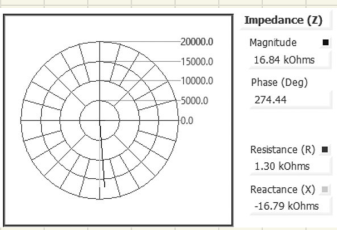
f=1Hz



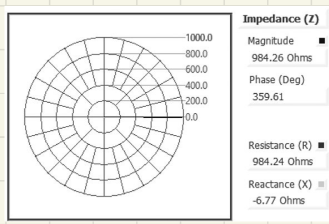
f=1000Hz



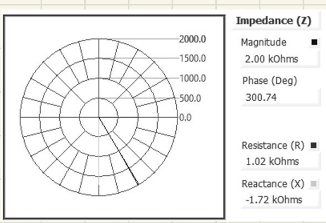
f=10Hz



f=10000Hz



f=100Hz



$$X_{Total} = X_R + X_C = R + \frac{1}{jwC} = R - j\frac{1}{wC}$$

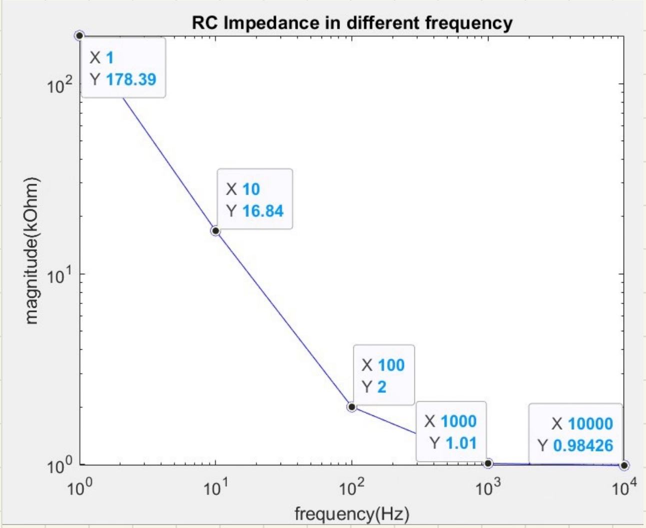
$$= 1000 - j\frac{1}{2\pi f}\cdot 10^6$$

(a) in low frequency, total impedance is dominate by capacitor

ex: in f=1 Hz, Reactance >> Resistance

(b) in high frequency, total impedance is dominate by resistor

ex: in f=10kHz, Resistance >> Reactance.



$$X_{total} = X_R + X_C$$
$$= 1000 - j \cdot \frac{1}{2\pi f} \cdot 10^6$$

Impedance Magnitude $= M$

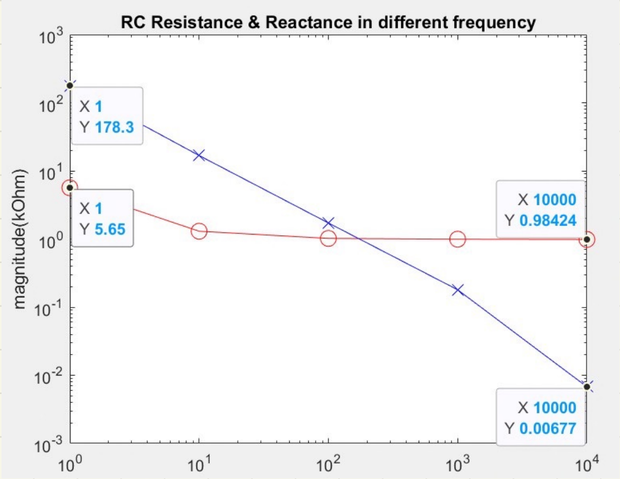
$$= \sqrt{X_R^2 + X_C^2}$$

(a) in low frequency:

$M \approx$ Reactance Magnitude

in high frequency:

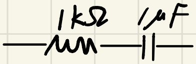
$M \approx$ Resistance



(b) Line with "x" sign is reactance magnitude in different frequency, Line with "o" is resistance magnitude in different frequency.

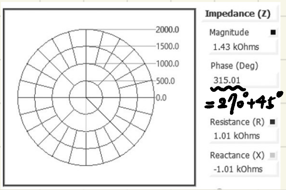
(c) "o" Line should converge to R in high frequency.

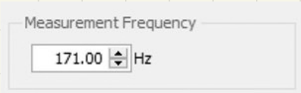
"x" Line should converge to 0 in high frequency (act as short)

4-9 

$$|X_C| = |X_R| \Rightarrow \frac{1}{\omega C} = R$$
$$\Rightarrow \frac{1}{2\pi f \cdot 10^{-6}} = 10^3$$
$$\Rightarrow f \approx \frac{10^3}{2\pi} \approx 159\,Hz$$

(calculated f)





We got equal impedance in $f = 171\,Hz$, the phase is $270° + 45° = 315°$

Ex5 Frequency Response of Inverting OP AMP

5-1 gain $= 10 \left(\frac{V}{V}\right)$

To obtain gain $= 10$, we choose

$R_f = 100\,\Omega$, $R_1 = 10\,\Omega$

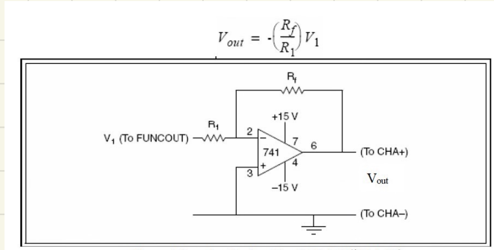
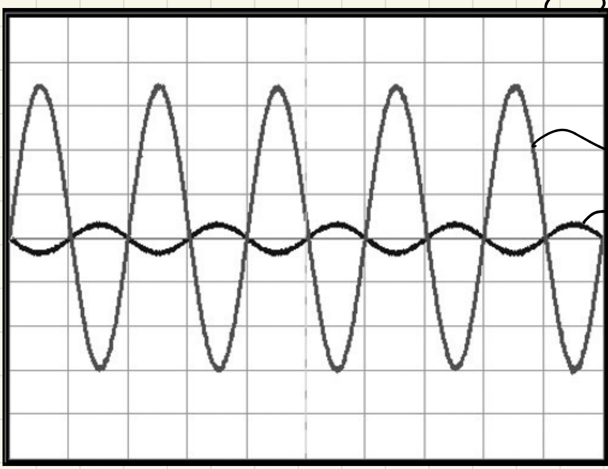


Figure 4. Inversing Op Amp Circuit (反向運算放大器)

5-10

500 μs

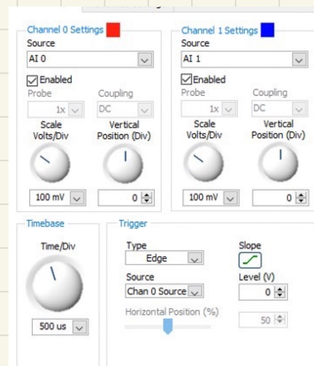


100 mV for both channel

output signal

input signal

*Signal is inverted!



Output : $V_{pp} = 656.74\,mV$, $RMS = 228.05\,mV$

Input : $V_{p.p} = 73.35\,mV$, $RMS = 22.94\,mV$

Gain @ $f = 1000\,Hz$

$$= \frac{228.05}{22.94} = 9.94 \left(\frac{V}{V}\right) \approx 10 \left(\frac{V}{V}\right)$$

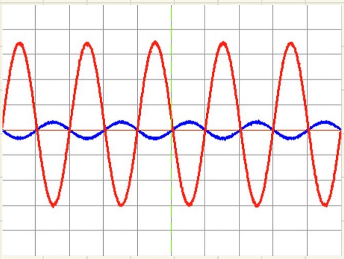
5-11

(Hz) frequency	100	500	1k	5k	10k	50k	100k	300k
(mV) Input Vpp	73.9	75.01	73.00	68.42	69.87	72.56	77.26	84.91
(mV) Output Vpp	659.53	658.91	650.33	636.08	632.65	551.71	446.66	200.03
(mV) Input RMS	22.97	22.92	22.86	22.75	22.63	25.45	28.91	31.82
(mV) Output RMS	229.95	228.85	226.96	227.66	222.91	204.58	162.54	76.08
(V/V) Gain	10.01	9.98	9.92	10.00	9.85	8.03	5.62	2.39

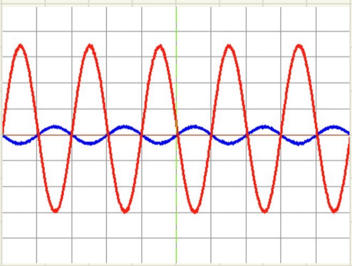
5-11 waveform

f=100Hz

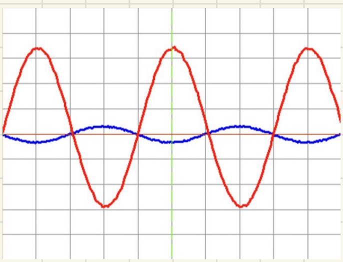
f=500Hz



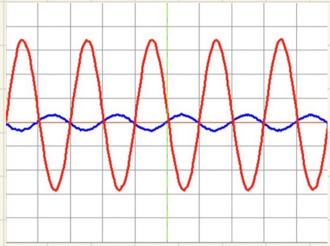
f=1kHz



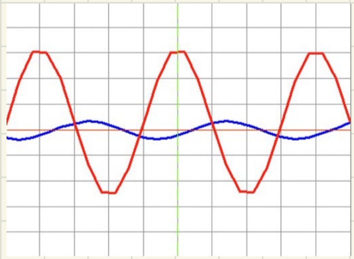
f=5kHz



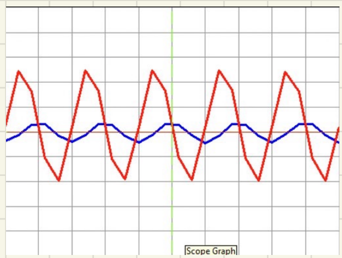
f=10kHz



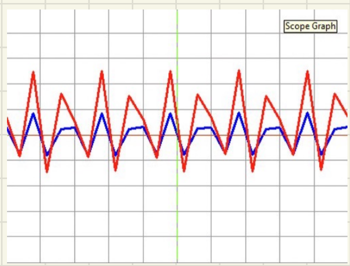
f=50kHz



f=100kHz



f=300kHz

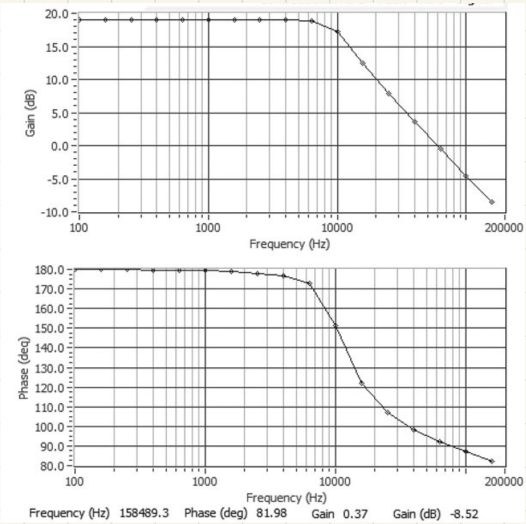


(a) Output signals distortion when frequency is over 50kHz, and phase no matter keep 180°.

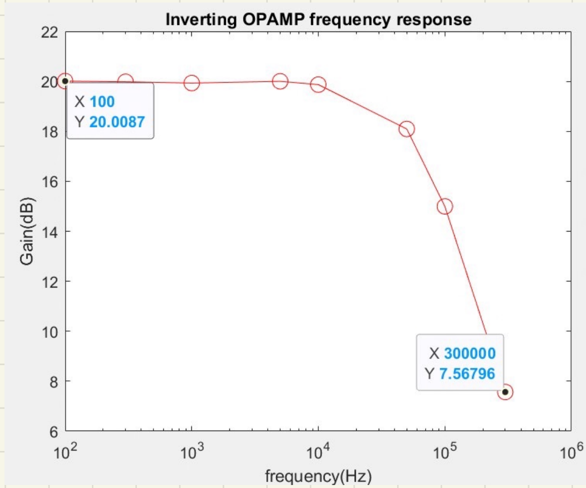
(b) Gain decrease as frequency increase, act as Low Pass Filter.

5-11 Bode Plot

From NI ELVIS



From Our Exp Data



* Source Code to plot the data:

```
%capacitance impedance in different frequency
figure(1)
frequency1=[1, 10, 100, 1000, 10000, 20000, 30000, 35000];
magnitude1=[175330, 16770, 1720, 181.43, 19.19, 8.74, 4.72, 3.46];
loglog(frequency1,magnitude1, "-ob");
xlabel('frequency(Hz)');
ylabel('magnitude(Ohm)');
title('Capacitor Impedance in different frequency');

%RC impedance in different frequency
figure(2)
frequency2=[1, 10, 100, 1000, 10000];
magnitude2=[178390, 16840, 2000, 1010, 984.26];
loglog(frequency2,magnitude2/1000, "-ob");
xlabel('frequency(Hz)');
ylabel('magnitude(kOhm)');
title('RC Impedance in different frequency');
```

```
%RC resistance and reactance in different frequency
figure(3)
R=[5650, 1300, 1020, 993.14, 984.24];
XC=[178300, 16790, 1720, 179.75, 6.77];
loglog(frequency2,R/1000, "-or",Markersize=10);hold on;
loglog(frequency2,XC/1000, "-xb", Markersize=10);hold on;
xlabel('frequency(Hz)');
ylabel('magnitude(kOhm)');
title('RC Resistance & Reactance in different frequency');

%Inverting OPAMP frequency response:
figure(4)
gain=[10.01, 9.98, 9.92, 10, 9.85, 8.03, 5.62 ,2.39];
frequency3=[100, 300, 1000, 5000, 10000, 50000, 100000, 300000];
semilogx(frequency3, 20*log10(gain), "-or",Markersize=10);
xlabel('frequency(Hz)');
ylabel('Gain(dB)');
title('Inverting OPAMP frequency response');
```

H. Question & Discussion:

Consider how well do the measured values agree with the theoretical values for the five lab exercises above? If the values do not match, why?

I think we did quite well in this lab, the measurement of 5 labs are quite same as we expected! A little bit error might come from the propagation delay / parasitic capacitance in connection wire @ high frequency, which can't be avoid!