Electronics Lab

This document contains two sample lab reports.

The instructions that were followed by the students have since been updated, so that your report may require a few different items.

1. Scanned image of a lab report for Lab #1.

All the required parts are included. The results are separated from procedure.

2. Scanned image of a lab report for Lab #2.

This is a perfect lab report for Lab #2.

Lab 1

D.C. Measurements

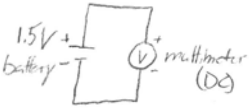
Preface: The objectives of this experiment are to become familiar with the multimeter, the prototyping board, the resistor color code, reading a schematic diagram and wiring a circuit. Additionally, study a voltage source, a current source and a voltage divider.

Experiments:

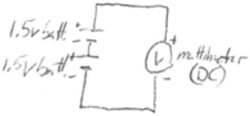
1. DC Voltage

(a) Batteries in series

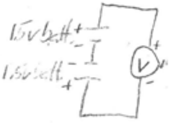
Apparatus -



(Part 1a)



(Part 1b)



(Part 2)

Instruments - Digital multimeter (Test Bench 388B Serial # 002K023) board with two size D 1.5V batteries, banana plug wires.

Procedure -

Part 1a - The voltages $V_{1_{meas}}$ and $V_{2_{meas}}$ of the two 1.5V batteries were measured. The uncertainty for this measurement was calculated based on the multimeter's specs. (DCV 0.50% rdg + 1 LSD)

Part 1b - The batteries were connected in series with forward polarity and the voltage (V^f_{meas}) measured. The uncertainty was calculated as in 1a.

Part 2 - The batteries were connected in series with reverse polarity and the voltage (V^r_{meas}) measured. The uncertainty was calculated as in 1a.

Procedure - The DC power supply was set to the different voltages and the voltage was measured with the multimeter. The uncertainty for this was calculated using the multimeter's specs. (DCV 0.50% rdg + 1 LSD)

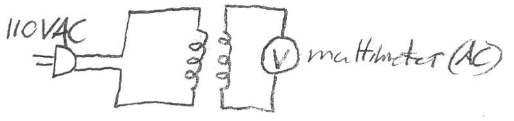
Results - $V_{1_{set}} = 5.0 \pm 0.2V$ $V_{1_{meas}} = 5.17 \pm .04V$

$V_{2_{set}} = 9.0 \pm 0.2V$ $V_{2_{set}} = 9.17 \pm .04V$

The power supply meter seems to be low by approximately 0.17V, given that the multimeter measurement is generally more reliable. The measured value is within the error bars.

2. AC voltage and frequency

Apparatus -



Instruments - Digital Multimeter (Test Bench 388B serial # CC2R0023), banana plug wires, ~8V transformer (Serial # 138031).

Procedure - With the primary of the transformer plugged into the AC outlet the AC output voltage from the transformer secondary was measured. Then the output frequency was measured using the multimeter. (no error measurements)

Results - $V_{secondary} = 8.59V$

$f_{secondary} = 60Hz$

three terminals, banana plug cables.

Procedure -

Part I - Two resistors within a factor of ten of each other were wired-up in series and the resistance was measured. The error was calculated using the multimeter specs (Ω 0.75% rdg + 1LSD) and then propagation of errors.

Part 2 - The same resistors were wired-up in parallel and the resistance across them was measured as before. The error was calculated as in part I.

Results -

$R_{1_{meas}} = 327.9 \pm 2.6\Omega$ $\quad R_{2_{meas}} = 0.556 \pm .005 \, k\Omega$

Part I - $R_{series_{meas}} = 0.883 \pm .008 \, k\Omega$

$$R_{series_{calc}} = R_1 + R_2 \pm \delta R_{series_{calc}}$$

$$\delta R_{series_{calc}} = [(2.6)^2 + (5)^2]^{1/2} = 5.6\Omega$$

$$R_{series_{calc}} = 327.9\Omega + 556\Omega \pm 5.6\Omega = 883.9 \pm 5.6\Omega$$

Part 2 - $R_{\substack{parallel \\ meas}} = 207.5 \pm 1.7\Omega$

$$R_{\substack{parallel \\ calc}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} \pm \delta R_{\substack{parallel \\ calc}}$$

$$\delta R_{\substack{parallel \\ calc}} = [(2.6)^2 + (5)^2]^{1/2} = 5.6\Omega$$

$$R_{\substack{parallel \\ calc}} = \frac{1}{\frac{1}{327.9\Omega} + \frac{1}{556\Omega}} \pm 5.6\Omega = 206 \pm 5.6\Omega$$

For parts one and two the calculated quantities agree well with the measured data, well within error bars.

Results - $I_{meas} = 2,329 \pm .024 mA$ (on 4mA setting)

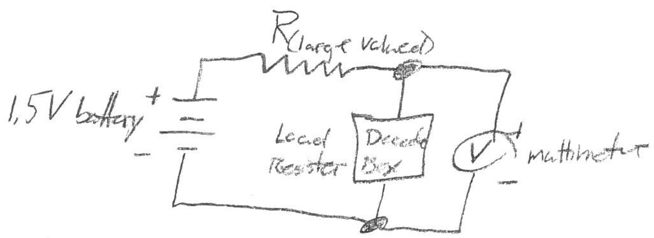
$V_{meas} = 1,541 \pm .009V$ (from earlier)

$$I_{calc} = \frac{V_{meas}}{R_{meas}} = 2.79\ mA$$

The measured and calculated values are noticeably different (outside of the measured error range). But we neglected to account for the internal resistance of the battery, plus the error bars for I_{calc} were not calculated.

7. Current Source

Apparatus -



Instruments - Multimeter (Test Bench 388I3 serial# 0021002З), banana plug cables, board with two size D 1,5V batteries, 10kΩ or higher resister, decade box (Type no. 1432-N serial # 13652 GenRadioCo.)

Procedure - The decade box was used as a load resistor. Values ranging from .01-20 times the value of the large resistor were used. The current through and the voltage across the load resister were measured with the multimeter. The error was calculated as before.

Results - $R_{meas}^{(large\ valued)} = 14.81 \pm .12 k\Omega$

$V_{meas}^{battery} = 1,541 \pm .009V$

(more on next page)

Procedure – The values of the resistors were measured and the input voltage was measured (V_{in}) using the multimeter, then the circuit was assembled as shown. (No error analysis.) then R_1 + R_2 were swapped and same measurements taken.

Results – $R_{1_{meas}} = 3.264 k\Omega$

$R_{2_{meas}} = 1.582 k\Omega$

$V_{in_{meas}} = 4.98 V$

$V_{out_{meas}} = 1.62 V$

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2} \quad \text{(Equation 1.32 Meyer)}$$

$$= \frac{1.582}{3.264 + 1.582} = 0.3265 \quad \text{(calculated value)}$$

$$\frac{V_{out}}{V_{in}} = \frac{1.62}{4.98} = 0.325 \quad \text{(measured value)}$$

⟸ The
erro

Now with $R_1 = 1.582 k\Omega$
+ $R_2 = 3.264 k\Omega$

we have → $V_{in} = 4.98 V$
$V_{out} = 3.35 V$

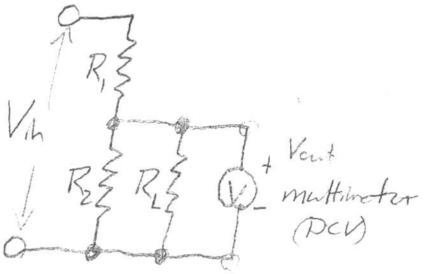
$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2} = \frac{3.264}{1.582 + 3.264} = 0.6735 \quad \text{(calculated value)}$$

$$\frac{V_{out}}{V_{in}} = \frac{3.35}{4.98} = 0.672 \quad \text{(measured value)}$$

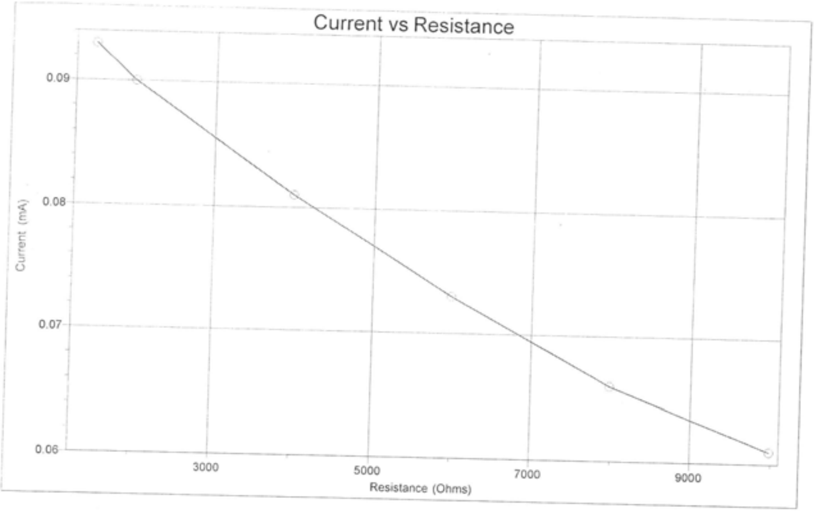
Still clear

(b) with load

Apparatus –



Instruments – Multimeter (Test Bench 388B Serial #02210023), banana plug cables, alligator clips, 3.3kΩ + 1.6kΩ resistor, Prototyping board (Heath Kit serial # 38266 model ETW-3200), Short solid wires, 1kΩ load resistor (R_L)


Current vs Resistance
0.09
0.08
0.07
0.06
Current (mA)
3000
5000
7000
9000
Resistance (Ohms)

11

Electronics Lab

This is a sample lab report for Lab #2.

The instructions that were followed by the student here have since been updated, so that your report may require a few different items.

Lab 2: AC Measurement

100

Preface

- Measure AC signal (amplitude, frequency, phase) using oscilloscope
- Study RC circuits

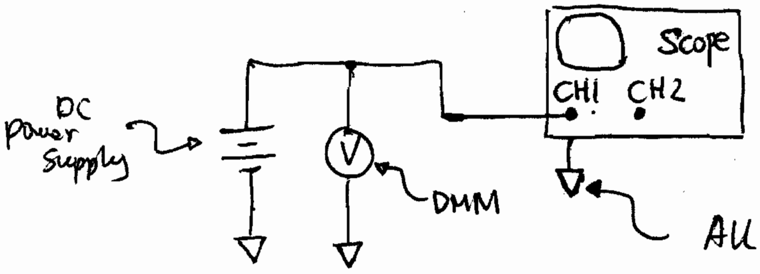
Experiment

1. Measurement of Voltages

(a) DC voltage

Apparatus: oscilloscope, digital multimeter, power supply

Procedure: set up scope;
set output voltage of power supply;
measure the output voltage using the scope & the multimeter.



All grounds are connected physically.

Voltage set by power supply	voltage measured by multimeter	scale of multimeter	voltage measured by scope	scale o
(1 ± 0.25)V	(1.252 ± 0.007)V	4V	(1.25±0.05)V	0.5V/Di
(2 ± 0.25)V	(2.322 ± 0.013)V	4V	(2.35±0.05)V	0.5V/Di
(3 ± 0.25)V	(3.260±0.017)V	4V	(3.30±0.05)V	0.5V/Div
half the minimum scale, i.e. $\frac{1}{2}$ x 0.5V	according to DMM's specification		half minimum division multiplied by scale, i.e 0.1 div × 0.5 V/Div	

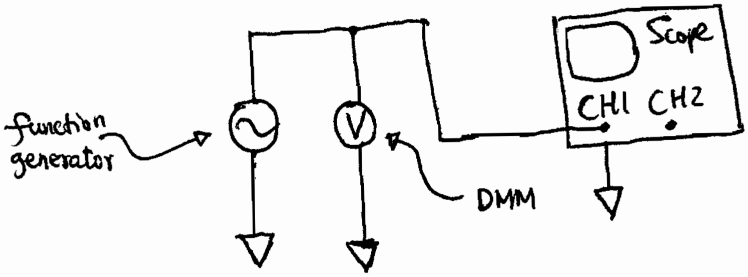
✓

The meter is more precise than oscilloscope, although the precision of oscilloscope's measurement can be improved by choosing smaller scale for verticle display.

(b) AC Voltages

Apparatus: oscilloscope, digital multimeter function generator

procedure: connect circuit;
set up function generator;
measure RMS voltage using multimeter & peak-to-peak voltage using scope.



Results:

V_{RMS} by DMM 400mV scale $= (342.4 \pm 1.8)$ mV $\sim\!\!\rightarrow \left(\frac{\delta V}{V}\right)_{DMM} = 0.5\%$

✓

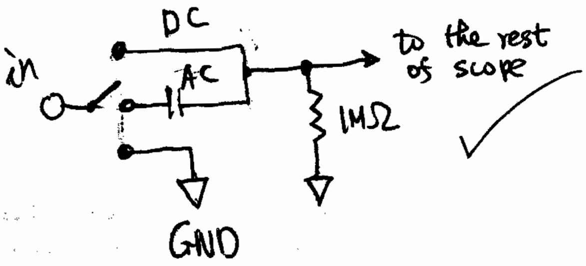
$V_{peak\text{-}to\text{-}peak}$ by scope 0.2 V/Div $= (1.00 \pm 0.02)$ V

$\div 2\sqrt{2}$ $\div 2\sqrt{2}$

V_{RMS} calculated using $V_{peak\text{-}to\text{-}peak}$ $= (0.35 \pm 0.01)$ V $\sim\!\!\rightarrow \left(\frac{\delta V}{V}\right)_{scope} = 2.9\%$

The meter is more precise, as seen from $\left(\frac{\delta V}{V}\right)_{scope} > \left(\frac{\delta V}{V}\right)_{DMM}$

(c) AC & DC coupling



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Difference: using DC coupling, one can see a verticle deflection of the trace when changing the offset; For AC coupling, there is no response to DC offset.
When using AC coupling, the signal passes a capacitor, which blocks the DC offse

2. Measurement of frequency

Apparatus: oscilloscope, digital multimeter, function generator

procedure: prepare the circuit as in 1(b) & (c);
measure frequency using multimeter;
measure time per cycle using scope & calculate frequency.

Frequency by multimeter	uncertainty in DMM measurement	Frequency by scope	uncertainty in scope measurement
10.25 kHz	0.13 kHz	10309 Hz (using 10us/Div)	103 Hz

using $\left|\frac{\delta f}{f}\right| = \left|\frac{\delta T}{T}\right|$

frequency

$|\delta f| = \left|f\frac{\delta T}{T}\right|$

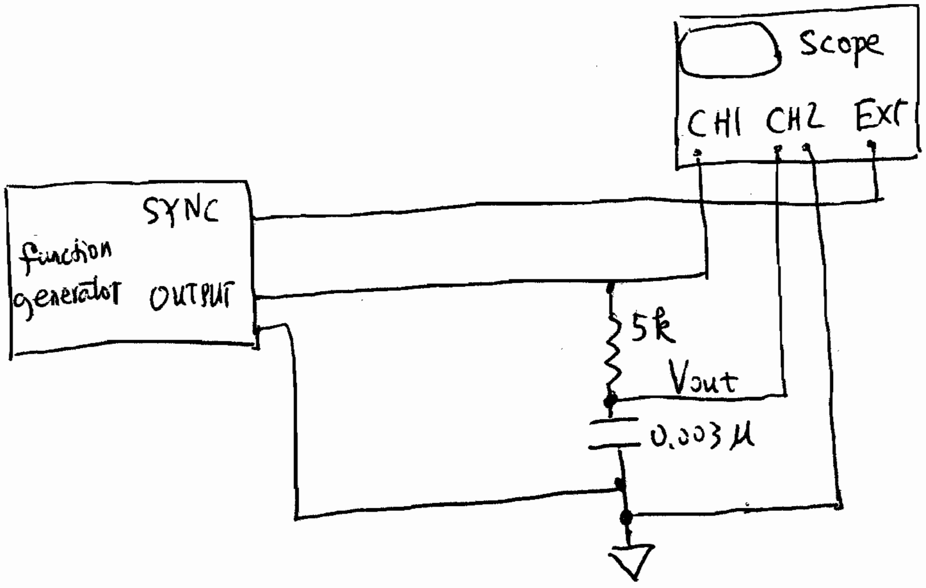
period

3. Time constant of an R-C circuit

Apparatus: osilloscope, digital multimeter,
function generator, 5kΩ resistor,
0.003 μF capacitor

Procedure:

Connect circuit
set function generator & the scope
measure charging & discharging times



Results:

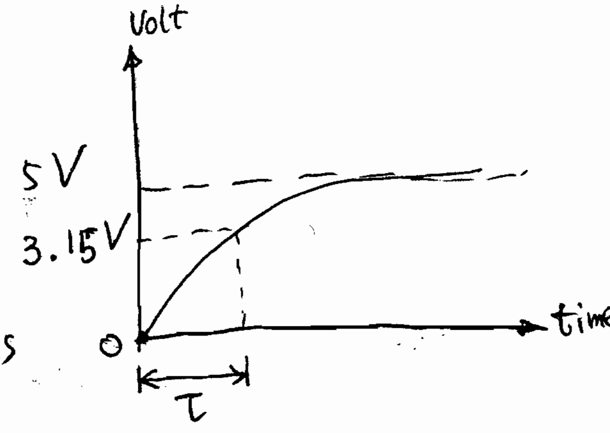
$R = 5.60 \, k\Omega \pm 0.04 \, k\Omega$

$C = 3.50 \, nF \pm 0.11 \, nF$

(a) Charging time

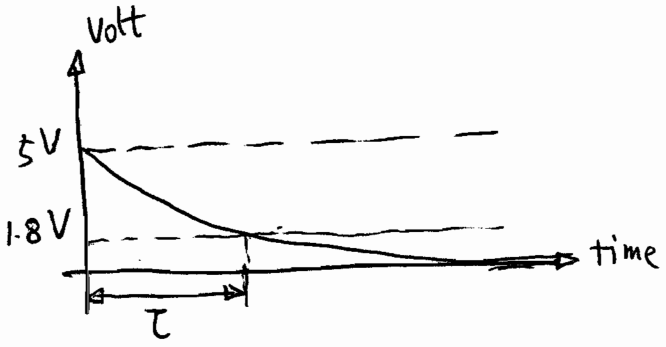
$T^{charge}_{measure}$ by scope 10 μs/Div $= (2.0 \pm 0.1) \times 10 \, \mu s$

$= 20.0 \, \mu s \pm 1.0 \, \mu s$



$\frac{T^{charge}_{measure}}{RC} = 1.02$

(b) Discharging time

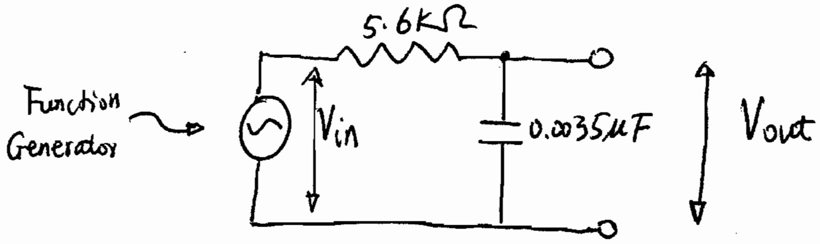


$\tau^{discharge}_{measure}$ by Scope 10us/Div $= (1.85 \pm 0.1) \times 10\mu s/Div$

$= 18.5\ us \pm 1.0\ \mu s$

$$\frac{\tau^{discharge}_{measure}}{RC} = 0.94$$

4. R-C Low-Pass Filter



Apparatus : same as 3

Procedure :

connect circuit as in 3

set function generator & scope

measure Vout & Vin at various frequencies.

measure time delay τ between Vout & Vin.

Results :

(a) Amplitude response

(i) see next page.

(ii) see next page.

(iii) The frequency at $\frac{V_{out}}{V_{in}} = 0.707$ is

$f_{measure} = (8.32 \pm 0.11)$ kHz

$f_{calculat} = \frac{1}{\ } = 8.12$ kHz

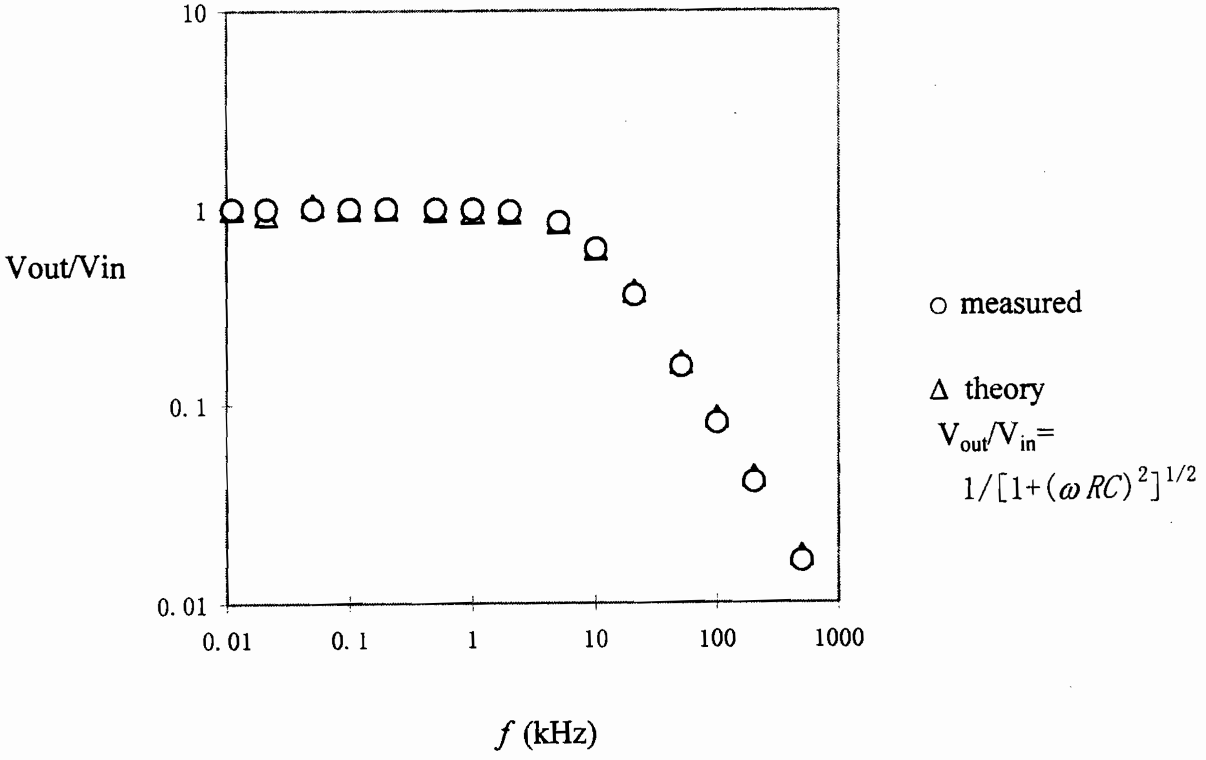
$\Rightarrow \frac{f_{measure}}{f_{calculat}} = 1.02$

R= 5.60 kΩ ± 0.04 kΩ
C= 3.50 nF ± 0.11 nF

f (Hz)	δ*f*	Vin	δVin	Vout	δVout	Vout/Vin (measure)	Vout/Vin (theory)
0.011	0.001	4.8	0.1	4.8	0.1	1.0	1.00
0.021	0.001	4.9	0.1	4.6	0.1	0.9	1.00
0.05	0.002	4.8	0.1	5.0	0.2	1.0	1.00
0.1	0.002	5.0	0.1	5.0	0.2	1.0	1.00
0.201	0.003	5.0	0.1	5.0	0.2	1.0	1.00
0.501	0.006	5.1	0.1	5.0	0.2	1.0	1.00
1.001	0.011	5.1	0.1	4.9	0.1	1.0	0.99
1.999	0.021	5.1	0.1	4.9	0.1	1.0	0.97
5.02	0.06	5.0	0.1	4.3	0.1	0.9	0.85
10.09	0.11	5.1	0.1	3.2	0.1	0.6	0.63
20.7	0.3	5.1	0.1	1.95	0.02	0.4	0.37
50.8	0.6	5.0	0.1	0.82	0.02	0.2	0.16
100.1	1.1	5.1	0.1	0.44	0.02	0.1	0.08
200.1	2.1	5.1	0.1	0.22	0.01	0.0	0.04
500.0	5.1	5.0	0.1	0.086	0.002	0.0	0.02

δ*A* = uncrtainty in *A*

spelling



Amplitude Response of A Low-Pass Filter

(b) Phase Response

(i) see next page

(ii) see next page

(iii) The phase angle at $f = \frac{1}{2\pi RC}$:

$f = 8.1$ kHz

$\theta_{measure} = 43.15° \pm 0.93°$

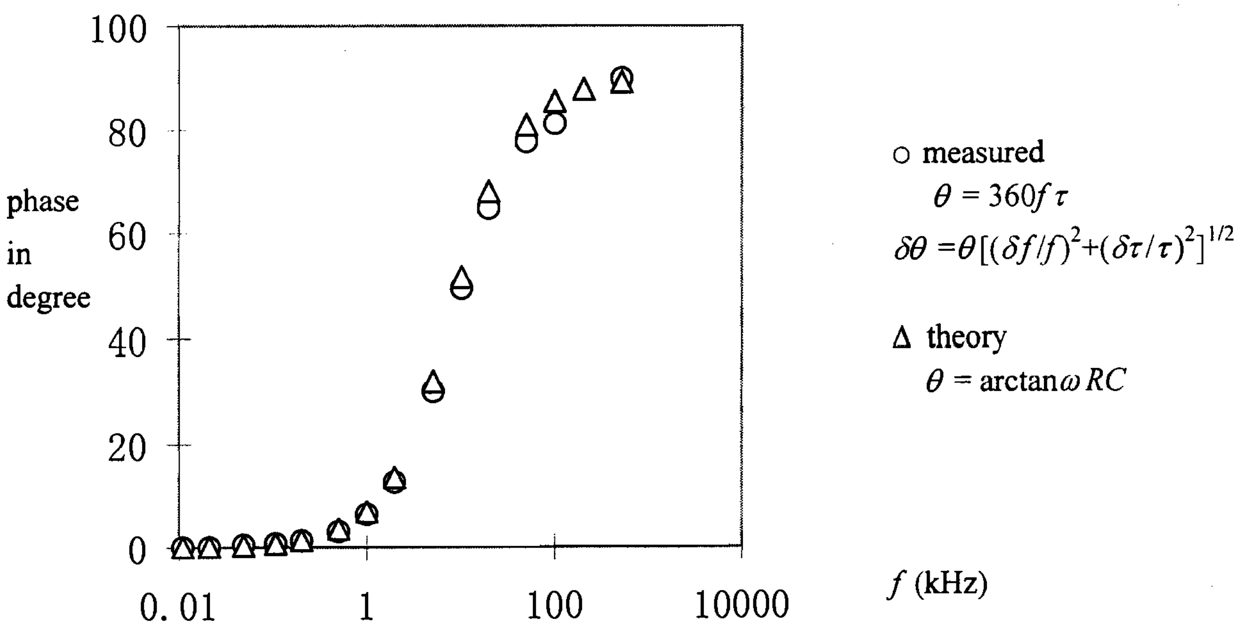
$\theta_{theory} = \arctan \omega RC$

$= \arctan (2\pi f \cdot RC)$

$= 45°$

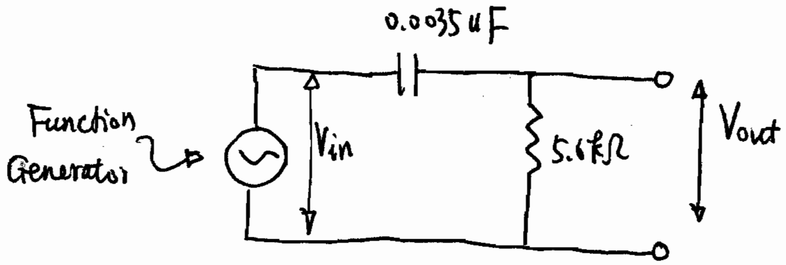
R= 5.60 kΩ ± 0.04 kΩ
C= 3.50 nF ± 0.11 nF

f(kHz)	δf (kHz)	delay in msec (τ)	$\delta\tau$ msec	phase in degrees θ (measure)	$\delta\theta$ degree	phase in degrees (theory)
0.011	0.003	0.0000	0.0001	0.000	0.000	0.078
0.021	0.003	0.0000	0.0001	0.000	0.000	0.148
0.049	0.003	0.030	0.005	0.529	0.096	0.346
0.108	0.004	0.020	0.005	0.778	0.197	0.762
0.204	0.005	0.018	0.002	1.322	0.150	1.439
0.502	0.008	0.018	0.001	3.253	0.188	3.538
1.001	0.013	0.0180	0.0005	6.486	0.199	7.028
1.962	0.023	0.0180	0.0005	12.714	0.382	13.584
5.08	0.08	0.0165	0.0005	30.18	1.03	32.033
10.26	0.13	0.0134	0.0002	49.49	0.98	51.653
20.01	0.23	0.0090	0.0002	64.83	1.62	67.937
50.1	0.8	0.0043	0.0001	77.6	2.2	80.830
100.1	1.3	0.00225	0.00005	81.1	2.1	85.403
202.0	2.3	0.00144	0.00002	104.7	1.9	87.741
509.0	5.4	0.00049	0.00001	89.8	2.1	89.131



Phase Response of A Low-Pass Filter

5. R-C High-Pass Filter



Apparatus : same as 3

Procedure :

connect circuit as above;
set function generator & scope
measure Vout & Vin at various frequencies

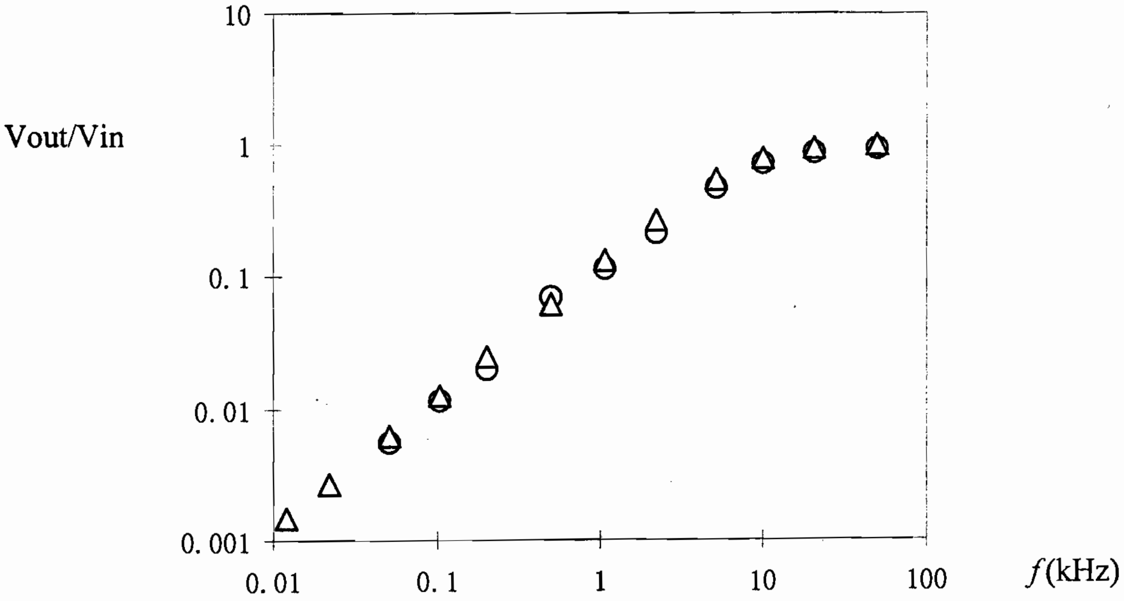
Results :

(i) See data table in the next page;
(ii) Amplitude response in the next page.

R= 5.60 kΩ ± 0.04 kΩ
C= 3.50 nF ± 0.11 nF

f (kHz)	δf	Vin	δVin	Vout	δVout	Vout/Vin (measure)	Vout/Vin (theory)
0.012	0.003	5.0	0.1	0.000	0.001	0.0	0.00
0.022	0.003	5.0	0.1	0.000	0.001	0.0	0.00
0.051	0.004	5.0	0.1	0.028	0.001	0.0	0.01
0.103	0.004	4.9	0.1	0.057	0.001	0.0	0.01
0.201	0.005	5.0	0.1	0.100	0.001	0.0	0.02
0.498	0.008	4.8	0.1	0.333	0.002	0.1	0.06
1.065	0.014	4.9	0.1	0.559	0.005	0.1	0.13
2.207	0.025	5.0	0.1	1.05	0.02	0.2	0.26
5.16	0.08	5.0	0.1	2.33	0.02	0.5	0.54
10.03	0.13	4.9	0.1	3.5	0.1	0.7	0.78
20.65	0.24	5.0	0.1	4.3	0.1	0.9	0.93
50.1	0.6	5.0	0.1	4.6	0.1	0.9	0.99

δA = uncrtainty in A;



○ measured

Δ theory

Vout/Vin = $\omega RC/[1+(\omega RC)^2]^{1/2}$

High-Pass filter