

ELECTRONICS QUANTITIES, OHM'S LAW, SERIES-PARALLEL RESISTIVE CIRCUITS AND POWER IN DC CIRCUIT

TOPICS:

1. ELECTRONIC QUANTITIES
2. OHM'S LAW
3. SERIES AND PARALLEL RESISTIVE CIRCUITS
4. POWER IN DC CIRCUIT

OBJECTIVES:

1. To measure voltage, current and resistance in a series DC circuit.
2. To demonstrate the relationship of resistance, current and voltage by using Ohm's law
3. To obtain values for resistance, voltage and current in a series/parallel resistive circuit by using Ohm's law
4. To measure DC power in a resistive circuit

LIST OF INSTRUMENTS:

1. F.A.C.E.T Base Unit
2. DC Fundamental Circuit Board
3. OHM'S LAW circuit block
4. LINEAR/NONLINEAR VARIABLE RESISTOR circuit block
5. SERIES/PARALLEL CIRCUIT circuit block
6. POWER circuit block
7. Multimeter

EXPERIMENT 1: ELECTRONIC QUANTITIES

Objective:

To measure voltage, current and resistance in a series DC circuit

Procedure:

1. Insert the DC FUNDAMENTALS circuit board into the base unit. Locate the OHM'S LAW circuit block.
2. Record the color-coded bands for resistors R1 and R2. Determine the value and tolerance of R1 and R2. Complete Table 1.1.
3. Measure and record the values of R1 and R2 using multimeter.
4. Insert a two-post connector between resistors R1 and R2.
5. Connect a voltmeter across the variable voltage source. Adjust the positive variable voltage source on the base unit until the voltmeter indicates 0 V.
6. Remove the voltmeter from the circuit. Select dc milliamps on the multimeter. Connect the ammeter between the two test points (between battery and R1). Record the current reading in Table 1.2.
7. Adjust the positive variable voltage source until the ammeter indicates 1.0 mA. Measure and record the voltage at the battery.
8. Adjust the positive variable voltage source to 5 V. Measure and record the current.
9. Adjust the positive variable voltage source from minimum to maximum. Record the minimum and maximum currents and the applied voltage.
10. Switch off the power source. Remove the OHM'S LAW circuit block.
11. Locate the LINEAR/NONLINEAR VARIABLE RESISTOR circuit block on the DC FUNDAMENTALS circuit board. Connect the circuit as shown in Figure 1.

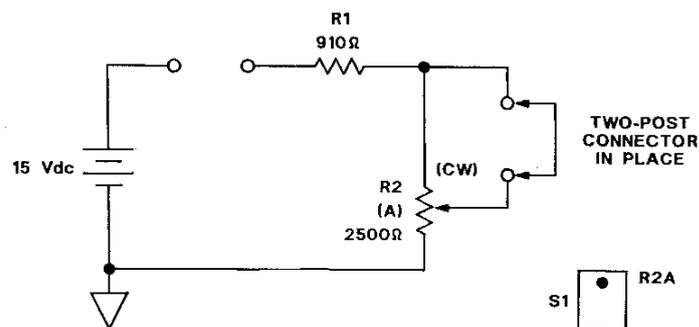


Figure 1 Basic Circuit Connection

12. Connect the ohmmeter across R2 (use the test point at the bottom of R3 and the test point at the top of R2).
13. Place switch S1 in the R2A position. Vary the R2A control from the extreme CCW position to the extreme CW position. Record the minimum and maximum resistance of R2A. Remove the ohmmeter from the circuit.

14. Turn on the power source.
15. Set R2A to its maximum CW position. Measure and record the voltage at the battery test points.
16. Connect the ammeter between the two test points. Measure and record the current flow when resistor R2A is set at its maximum CW and CCW positions.
17. Turn off the power supply. Remove all circuit board connections.

Result:

Table 1.1

Resistor	Color-coded band	Value	Tolerance	Measured Value
R1				
R2				

Table 1.2

Step	Parameter / Quantity	Measured Value
6	I	
7	V	
8	I	
9	I_{\min} & V_{\min}	
9	I_{\max} & V_{\max}	
13	$R2A_{\min}$ & $R2A_{\max}$	
15	V	
16	I (R2A - maximum CW)	
16	I (R2A - maximum CCW)	

Question:

1. Does the measured values of R1 and R2 is within the tolerance of the calculated values?
2. What is the relationship between current and voltage?
3. What is the relationship between resistance and voltage?

EXPERIMENT 2: OHM'S LAW

Objective:

To demonstrate the relationship of resistance, current and voltage by using Ohm's law

Procedure:

1. Place a two-post connector between R1 and R2 in the OHM'S LAW circuit block. Measure and record the total resistance.
2. Turn on the power source.
3. Select the volts function of the multimeter. Connect the multimeter across the variable voltage source in the OHM'S LAW circuit block. Adjust the positive supply to 10 V.
4. Connect the multimeter between the variable voltage source and resistor R1. Measure and record the current.
5. Adjust the variable voltage source to the values stated in Table 2.1. For each value of voltage, measure and record the current.

Result:

Table 2.1

Variable voltage source	Measured Current
10 V	
8 V	
6 V	
4 V	
2 V	
0 V	

Question:

1. Plot a graph of voltage versus current. Calculate the total resistance.
2. Compare the total resistance obtain from the graph with the measured values.

EXPERIMENT 3: SERIES-PARALLEL RESISTIVE CIRCUITS

Objective:

To obtain values for resistance, voltage and current in a series-parallel resistive circuit

Procedure:

1. Locate the SERIES-PARALLEL CIRCUIT circuit block. Connect the circuit shown in Figure 2.
2. Measure and record the total resistance, R_T , total current, I_T , current through R_2 , I_{R_2} and current through R_3 , I_{R_3} .
3. Measure and record V_{R_1} and V_{RE} .

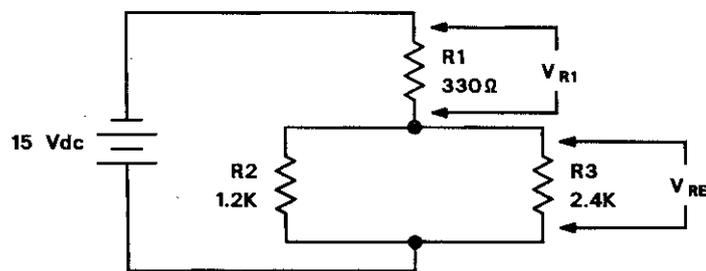


Figure 3 Series-parallel resistive circuit

Question:

1. Calculate total resistance, R_T . Compare with the measured values.
2. Verify Kirchhoff Current Law (KVL).
3. Verify Kirchhoff Voltage Law (KVL).
4. **In the long report**, calculate total resistance, R_T , total current, I_T , current through R_2 , I_{R_2} and current through R_3 , I_{R_3} . Compare with the measured values.
4. **In the long report**, calculate voltage drop across R_1 (V_{R_1}) and voltage drop across parallel resistors (V_{RE}) using voltage divider rule. Compare with the measured value.

EXPERIMENT 4: DC POWER

Objective:

To measure DC power in a resistive circuit

Procedure:

1. Locate the POWER circuit block. Connect the circuit shown in Figure 3. Place the switch that is in the POWER circuit block in position A.
2. Record the color-coded bands for resistors R1, R2, R3 and R4. Determine the value and the tolerance for each resistor.
3. Measure and record voltage drop across R1 and R2.
4. Measure and record current flow through R3.
5. Move the switch from position A to position B. Measure and record voltage across R4.
6. Turn off the power source.

Note: Produce your own Table to record all the measured values.

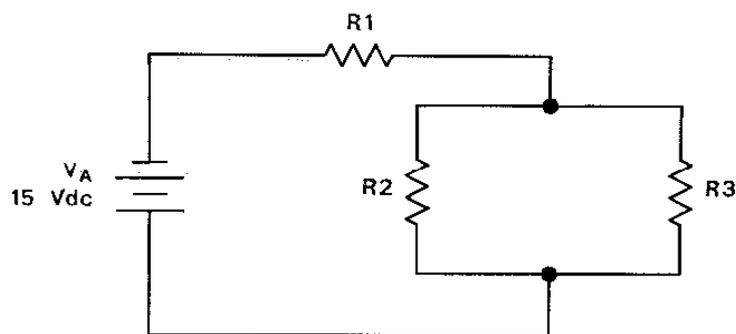


Figure 4 Series-parallel resistive circuit

Question:

1. Calculate power dissipated by R1, R2 and R3.
2. Calculate power supplied by the voltage source. Compare power dissipated in the circuit and power supplied by the voltage source.
3. Calculate total power dissipated by the parallel branch of the circuit.
4. Calculate power dissipated by R4.



**MALAYSIA-JAPAN INTERNATIONAL INSTITUTE OF
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**ELECTRONIC ENGINEERING LABORATORY I
(SMJE 1062)**

2018/2019 – SEMESTER 1

FUNDAMENTAL OF ELECTRICAL CIRCUITS

LABORATORY SHEET 2

TOPICS

1. AC MEASUREMENT
2. INDUCTIVE
3. INDUCTIVE REACTANCE

OBJECTIVES:

1. To measure and obtain amplitude, frequency, and phase measurements of ac waveforms by using an oscilloscope
2. To measure frequency and phase angle by using an oscilloscope
3. To describe the effect of inductance on a circuit

INSTRUMENTS REQUIRED:

1. F.A.C.E.T Base Unit
2. Virtual Oscilloscope
3. AC 1 Fundamental circuit board
4. Virtual Generator
5. Multimeter

EXPERIMENT 1: AC MEASUREMENT

Objective:

To measure and obtain amplitude, frequency, and phase angle of ac waveforms by using an oscilloscope

Procedure:

1. Turn off the power sources. Insert the **AC 1 FUNDAMENTALS** circuit board into the base unit. Turn on the power sources.
2. Turn on virtual instruments and the computer provided at each station. Select and open *Multi Channel* software at the desktop.
3. Locate the **DC/AC waveforms** circuit block. Use a two-post connector to connect the generator source from the *virtual instrument* (V.I) to R1. Set frequency of V.I to 60 Hz (set at the generator of *Multi Channel* software).
4. Connect Channel 2 of the V.I across R1. Adjust the generator amplitude (from the *Multi Channel* software) to produce a sine wave display of 6 divisions high. Complete Table 1-1.
5. Disconnect the probe from the circuit. Measure V_{R1} with the multi-meter. Record your result in Table 1-1.
6. Adjust the generator output so that V_{R1} is $10 V_{pk-pk}$.
7. Set the time base control to $50 \mu s/div$. Adjust the frequency of the generator for a waveform cycle that is 8 divisions wide along the horizontal axis (time axis).
8. Record the period (T) and frequency of this waveform. Record the result in Table 1-2.
9. Locate the **PHASE ANGLE** circuit block. Connect the generator (from V.I) to the PHASE ANGLE circuit block, and turn on the generator. Set the generator for sine wave output. Turn potentiometer R2 fully clockwise (CW). Connect Channel 1 probe to the input of the circuit block (generator source). Connect the channel 2 probe to the output of the circuit block (across C1). Set both channel ground references to the center graticule line.
10. Set the generator output for $6 V_{pk-pk}$ at 1 kHz using the oscilloscope. Record the phase angle between the input and output waveforms in Table 1-3.
11. Slowly turn the potentiometer R2 completely counter clockwise (CCW). Observe the phase shift.
12. Adjust the frequency so that one cycle of the waveform takes up exactly 8 divisions. Record how many degrees each horizontal division represents in Table 1-3.
13. Turn off power sources to all equipment, and remove all circuit board connections.

Result:

Table 1-1

Step	V_{R1}				
	Peak-to-Peak	Peak	RMS	AVG	Multimeter Display
4					

Table 1-2

Step	Parameter	Value
8	Period, T	
	Frequency, f	

Table 1-3

Step	Description	Value
10	Phase angle	
11	Phase angle	
12	How many degrees does each horizontal division represent?	

Question:

1. Does a phase shift occur? Discuss.

EXPERIMENT 2: SERIES RL

Objective:

To compare the effect of voltage induced through inductor (L) during the changes of frequencies.

Procedure:

1. Locate the **INDUCTANCE/INDUCTIVE REACTANCE** circuit block. Use the multimeter to measure and record the coil resistance of inductor L3 (R_{L3}).
2. Connect the circuit shown in Figure 2-1 on the **INDUCTANCE/INDUCTIVE REACTANCE** circuit block (be sure to short out current sensing resistor R2 with a two-post connector). Turn on the power source and adjust the positive variable supply to 8 Vdc.
3. Measure and record the circuit current (I_{dc}) and the voltage drop across inductor L3 (V_{L3dc}) with the multimeter. Record the result in Table 2-1.
4. Use your measured values of I_{dc} and V_{L3dc} to calculate the coil resistance of L3.
5. Connect the circuit in Figure 2-2. Adjust generator of *Multi-Channel* software for a 10 V_{pk-pk}, 20 kHz sine wave.
6. Measure and record the circuit current (I_{ac}) using oscilloscope of *Multi-Channel* software.
7. Measure and record the voltage of R2 using oscilloscope of *Multi-Channel* software. Calculate the I_{ac} using $I_{ac} = V_{R2}/R2$. Compare the measured and calculated results.
8. Measure and record the voltage induce across L3 (V_{L3ac}) with the oscilloscope of *Multi Channel* software.
9. Use the measured values of I_{ac} and V_{L3ac} to calculate and record the impedance of L3 (Z_{L3}).
10. Compare the result of Step 9 and Step 8. Discuss.
11. Change the input frequency of generator of *Multi-Channel* software to 60 kHz sine wave. Repeat steps 5 to 10.

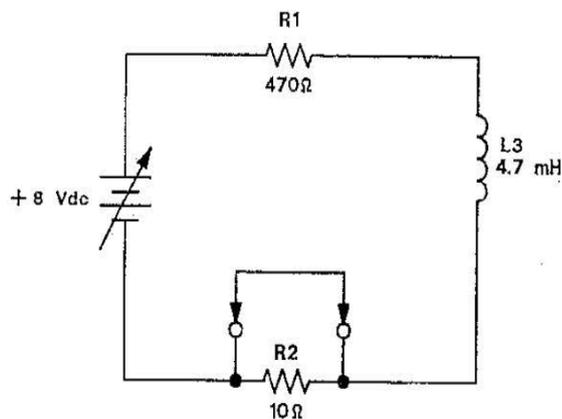


Figure 2-1: Series RL Circuit (dc)

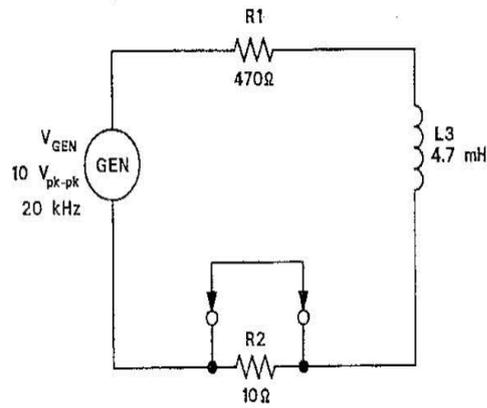


Figure 2-2: Series RL Circuit (ac)

Result:

Table 2-1

Step	Description	Value	
		$f_s = 20 \text{ kHz}$	$f_s = 60 \text{ kHz}$
1	Coil resistance, R_L		
3	Circuit current, I_{dc}		
	Voltage , V_{L3dc}		
4	Calculated resistance of L3		
6	Circuit current (I_{ac})		
7	Voltage of R2 (V_{R2})		
	Calculated I_{ac}		
	Comparison of Step 6 and 7		
8	Voltage drop across L3 (V_{L3ac})		
9	Impedance of L3 (Z_{L3})		

Question:

1. Is there any difference of output voltage at L3 during the changes of f_s ? Discuss.
2. Discuss on relationship between impedance of inductor and frequency.

EXPERIMENT 3: SERIES RL & PARALLEL RL

Objective:

To describe the effect of inductance on a circuit during series RL and parallel RL

Procedure:

1. Locate the **INDUCTANCE/INDUCTIVE REACTANCE** circuit block and connect the circuit shown in Figure 3-1. Measure coil resistance of R_{L1} , R_{L2} and total R_{L1} & R_{L2} . Record in Table 3-1.
2. Turn on the power source and adjust generator for a 60 kHz, 10 V_{pk-pk} sine wave (remember to set frequency and amplitude using virtual generator of *Multi-Channel Software*).
3. Measure the total circuit current (I_T), voltage of V_{L1} , V_{L2} and $V_{L1} + V_{L2}$. Compare I_T , V_{L1} , V_{L2} and $V_{L1}+V_{L2}$ with the calculated values. Record in Table 3-1.
4. Turn off the power source and connect the circuit shown in Figure 3-2. Measure coil resistance of R_{L3} , R_{L4} and total $R_{L3} + R_{L4}$. Record in Table 3-2.
5. Use the existing input settings, turn on the power source. Measure current flowing through L3 (I_{L3}) and L4 (I_{L4}) and voltage of V_{L3} , V_{L4} and V_{L3}/V_{L4} . Compare I_{L3} , I_{L4} , V_{L3} , V_{L4} and V_{L3}/V_{L4} with the calculated values. Record in Table 3-2.

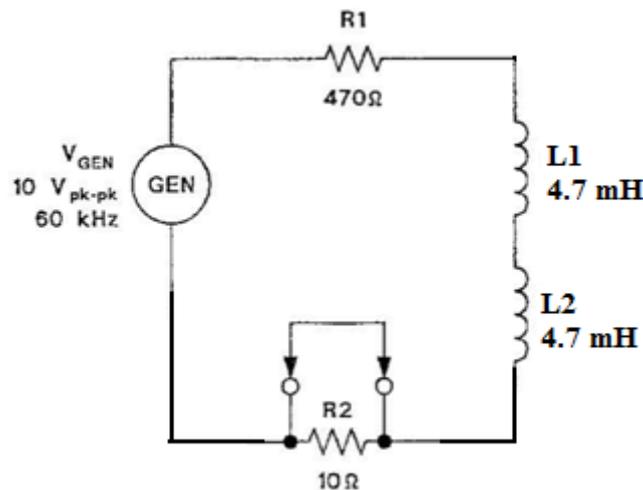


Figure 3-1: Series RL Circuit

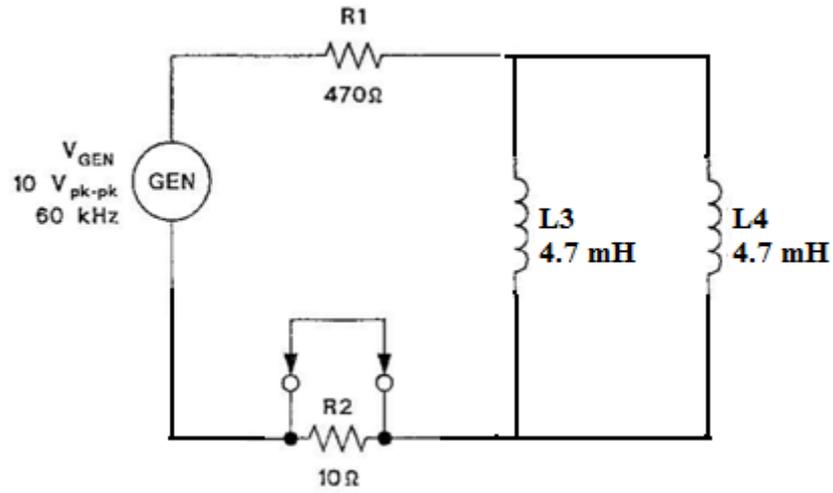


Figure 3-2: Parallel RL Circuit

Results:

Table 3-1

Step	Description	Measured Value	Calculated Value
1	R_{L1}		
	R_{L2}		
	$R_{L1} + R_{L2}$		
3	I_T		
	V_{L1}		
	V_{L2}		
	$V_{L1} + V_{L2}$		

Table 3-2

Step	Description	Measured Value	Calculated Values
4	R_{L3}		
	R_{L4}		
	$R_{L3}+R_{L4}$		
5	I_{L3}		
	I_{L4}		
	V_{L3}		
	V_{L4}		
	$V_{L3} // V_{L4}$		

Questions:

1. What is(are) the difference(s) between I_T and I_{L3} (or I_{L4})?
2. Compare both circuits in term of voltage induced at the total inductors. Discuss.



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**ELECTRONIC ENGINEERING LABORATORY I
(SMJE 1062)**

2018/2019 – SEMESTER 1

LABORATORY SHEET

FUNDAMENTAL OF ELECTRICAL CIRCUITS

(UNIT 3)

FUNDAMENTAL OF ELECTRICAL CIRCUITS

LABORATORY SHEET 3

CAPACITANCE AND CAPACITIVE REACTANCE

TOPICS

1. CAPACITANCE
2. CAPACITIVE REACTANCE

OBJECTIVES:

1. To describe the effect a capacitor has on dc and ac circuits by using measured values
2. To determine the characteristics of resistive-capacitive (RC) circuits by using an oscilloscope
3. To determine capacitive reactance (X_C) by using calculated and measured values

MATERIALS REQUIRED:

1. F.A.C.E.T Base Unit
2. Virtual Oscilloscope
3. AC 1 Fundamental circuit board
4. RC TIME CONSTANTS circuit block
5. CAPACITANCE/CAPACITIVE REACTANCE circuit block
6. Virtual Generator
7. Power Supply, 15 Vdc
8. Multimeter

EXPERIMENT 1: CAPACITANCE

Objective:

To describe the effect a capacitor has on dc and ac circuits by using measured values

Procedure:

1. Turn off the power sources. Insert the AC 1 FUNDAMENTALS circuit board into the base unit. Turn on the power sources.
2. Locate the RC TIME CONSTANTS circuit block, and connect the circuit shown in Figure 1. Set up the oscilloscope for operation, and set the vertical coupling for channels 1 and 2 to DC.
3. Switches S1 and S2, which are normally open, must be pushed and held in order to be closed.
4. Use the multimeter to measure the voltage across capacitor C1. If you measure a voltage, then C1 has a charge on it. Switch S2 provides a means of discharging C1 through R3. Press S2 for several seconds until 0 V is measured across C1.
5. Switch S1 applies the 15 Vdc to the circuit. While monitoring the oscilloscope for voltage across capacitor C1, close (press) S1 and hold it closed. Does the capacitor charge up to 15 V when the dc voltage is applied? Write down your observation in Table 1.
6. Hold S1 closed for approximately 15 seconds. To remove the dc source from the circuit, open (release) S1 while observing the voltage across C1. Does the charge on capacitor C1 remain even after the dc source is removed? Is the charge constant, decreasing or increasing? Write down your observation in Table 1.
7. Discharge the capacitor by pressing S2 until the voltage across C1 is zero. Remove the oscilloscope probe from the circuit.
8. Set the multimeter to read dc current. Replace the two-post connector between S1 and R2 with the multimeter probes. Set the range of the multimeter to read microamps (μA).
9. While monitoring the multimeter display, close S1 and hold it closed for about 15 seconds. Based on the reaction of the multimeter display, was current flowing while capacitor C1 was charging? Write down your observation in Table 1. Discuss why the current is flowing.
10. Based on the reaction of the multimeter display, observe whether the current flowing or not after the capacitor became fully charged. Write down your observation in Table 1.
11. Locate the CAPACITANCE/CAPACITIVE REACTANCE circuit block, and connect the circuit shown in Figure 2. Set the vertical coupling controls for both channels to AC.
12. Use the oscilloscope to adjust VGEN for a 10 Vpk-pk, 1 kHz sine wave.
13. Measure and record circuit current (I) by using current-sensing resistor R2. Record the result in Table 1.
14. Based on the result of Step 13, does the current flowing in the circuit indicate that capacitor C3 is passing ac? Write down the discussion in Table 1.
15. Measure and record the voltage drop across C3 (V_{C3}). Record the result in Table 1.
16. Using the value of I in Step 13 and the value of V_{C3} in Step 15, determine and record the impedance of capacitor C3 ($Z_{C3} = V_{C3}/I$). Record the value in Table 1.

17. Even though capacitor C3 is passing ac, is C3 presenting opposition to current flow? Write down the discussion in Table 1.
18. Monitor the circuit current on the oscilloscope by observing the voltage across current-sensing resistor R2. While observing the oscilloscope display, place CM switch 10 in the ON position to increase the capacitance of C3 to 0.2 μF . Observe the change in circuit current when the capacitance is increased. Write down in Table 1.
19. Return CM switch 10 to the OFF position. Increase the generator frequency while observing the circuit current on the oscilloscope. Observe the change in current when the frequency is increased. Write down in Table 1
20. Readjust the generator frequency to 1 kHz. Connect the channel 1 input of the oscilloscope to measure V_{C3} and the channel 2 input to measure V_{R2} (circuit current and V_{R2} have identical phase). Measure and record the phase angle (θ) between the circuit current and V_{C3} (use V_{C3} as the reference). Does the circuit current lead or lag the capacitor voltage? Sketch the waveform of voltage and current. Write down the discussion in Table 1.
21. Turn off the power source.

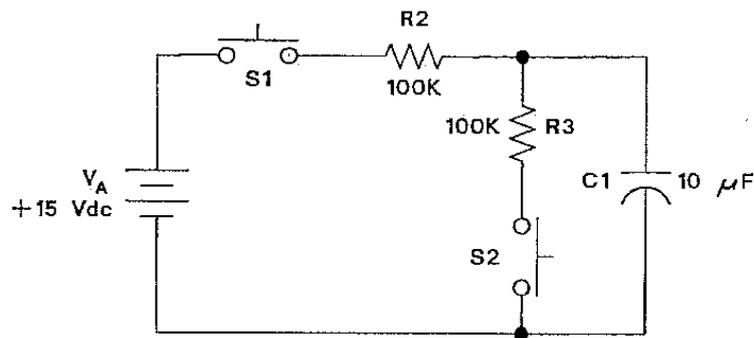


Figure 1 Capacitor test circuit with dc source

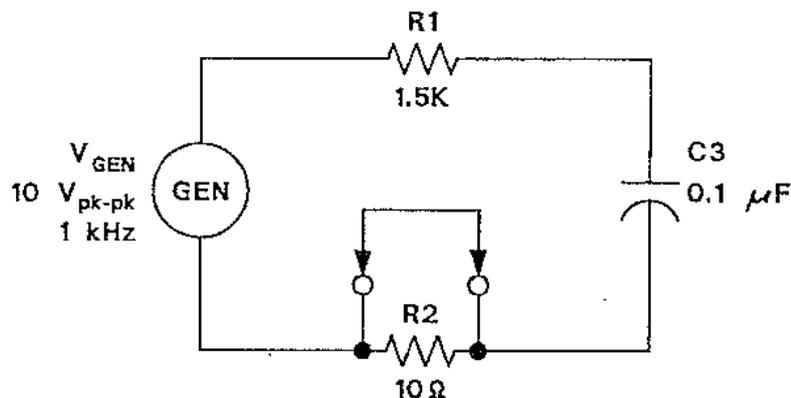
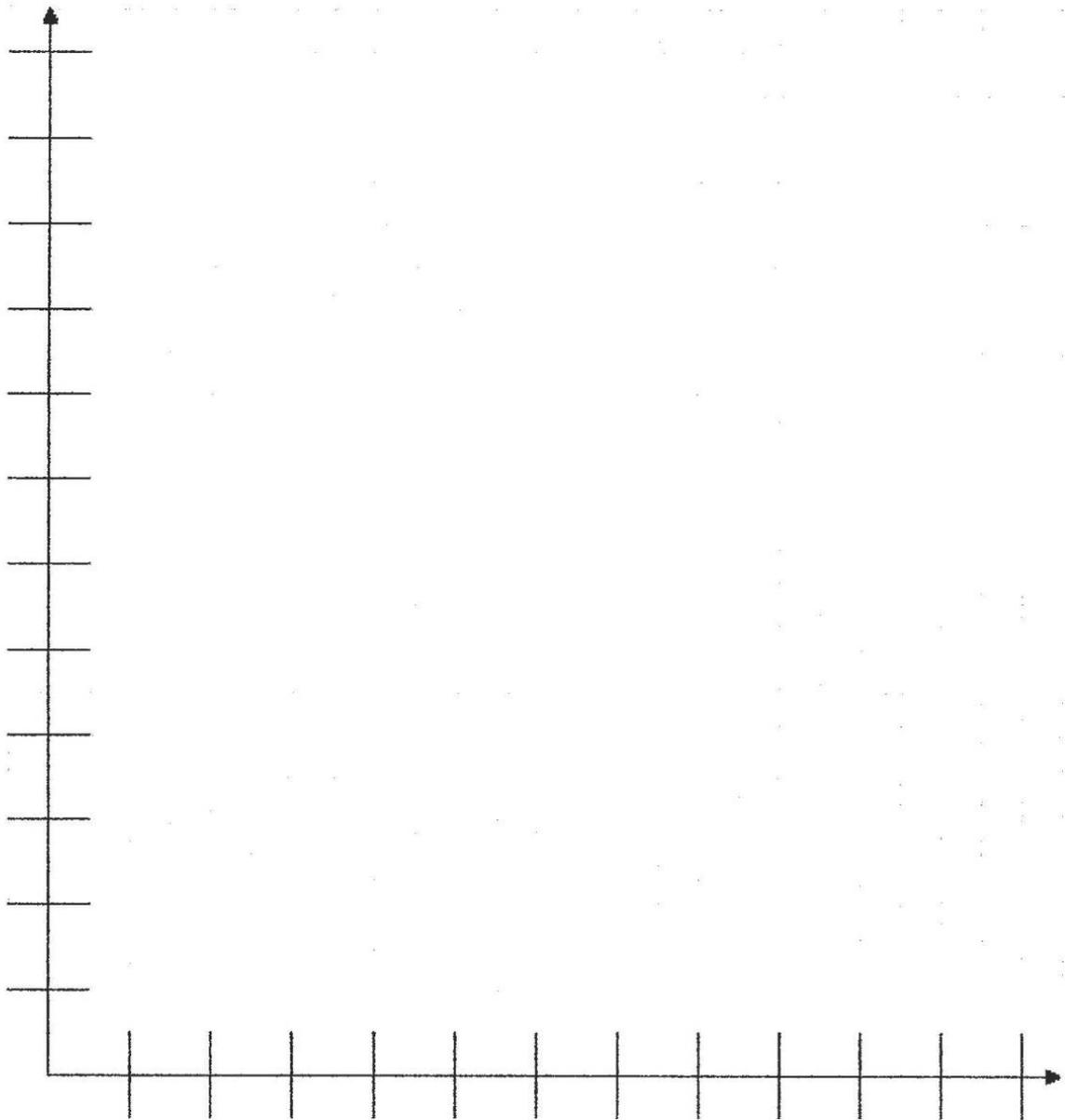


Figure 2 Capacitor test circuit with ac applied

Result:**Table 1**

No.	Step	Description	Value/Answer
1	5	Does the capacitor charge up when the dc voltage is applied?	YES/NO
2	6	Does the charge on capacitor C1 remain even after the dc source is removed?	YES/NO
3	9	Was current flowing while capacitor C1 was charging?	YES/NO Discussion:
4	10	Current flowing	
5	13	Circuit current (I)	
6	14	Does the current flowing in the circuit indicate that capacitor C3 is passing ac?	YES/NO Discussion:
7	15	Voltage drop across C3 (V_{C3})	
8	16	Impedance of capacitor C3(Z_{C3})	
9	17	Is C3 presenting opposition to current flow	YES/NO Discussion:
10	18	Change in circuit current (Increased Capacitance)	
11	19	Change in circuit current (Increased Frequency)	
12	20	Phase angle (θ)	
13	20	Does the circuit current lead or lag the capacitor voltage?	Discussion:

Step 20: Sketch the waveform of voltage and current



EXPERIMENT 2: CAPACITIVE REACTANCE

Objective:

- To determine the characteristics of resistive-capacitive (RC) circuits by using an oscilloscope
- To determine capacitive reactance (X_C) by using calculated and measured values

Procedure:

1. Turn off the power sources. Insert the AC 1 FUNDAMENTALS circuit board into the base unit. Turn on the power sources.
2. Locate the CAPACITANCE/CAPACITIVE REACTANCE circuit block, and connect the circuit shown in Figure 3. Adjust VGEN for a 10 V_{ok}-pk, 1 kHz sine wave (remember to set the frequency and amplitude with the oscilloscope). Calculate and record the capacitive reactance of capacitor C3 ($X_{C3} = 1/2\pi fC$). Record the value in Table 2.
3. Measure and record the total circuit current (I) by using current sensing resistor R2 ($I = V_{R2}/R2$). Record the value in Table 2.
4. Measure and record the voltage drop across capacitor C3 (V_{C3}). Record the value in Table 2.
5. Use I and V_{C3} to determine the measured value of capacitive reactance X_{C3} (X_{C3} (measured) = V_{C3}/I). Record your result in Table 2. Compare the measured value in Step 4 with the calculated value in Step 2.
6. Place CM switch 9 in the ON position to decrease the value of C3 to 0.05 μ F. Readjust VGEN for 10 V_{pk}-pk if necessary. Calculate and record the new capacitive reactance of C3 (X_{C3}).
7. Measure I and V_{C3} , and determine the new measured value of X_{C3} . Record your result in Table 2. Observe the change of capacitive resistance with decreasing capacitance. Write down the discussion in Table 2.
8. Return CM switch 9 to the OFF position. Readjust VGEN for 10 V_{pk}-pk if necessary.
9. Decrease the frequency of the generator to 500 Hz. Remeasure I and V_{C3} , and determine the new measured value of X_{C3} . Record your result in Table 2. Compare this measurement with the initial X_{C3} measurement (Step 5). Write down the discussion on the change of the capacitive reactance with decreasing frequency in Table 2.
10. Readjust the generator frequency to 1 kHz. Decrease the amplitude of VGEN to 8 V_{pk}-pk. Measure I and V_{C3} , and determine X_{C3} . Record X_{C3} in Table 2.
11. Compare Step 10 with initial measurement (Step 5). Did X_{C3} increase, decrease, or remain the same in relation to the initial value of X_{C3} measured? Write down your observation and reason in Table 2.
12. Turn off the power source.

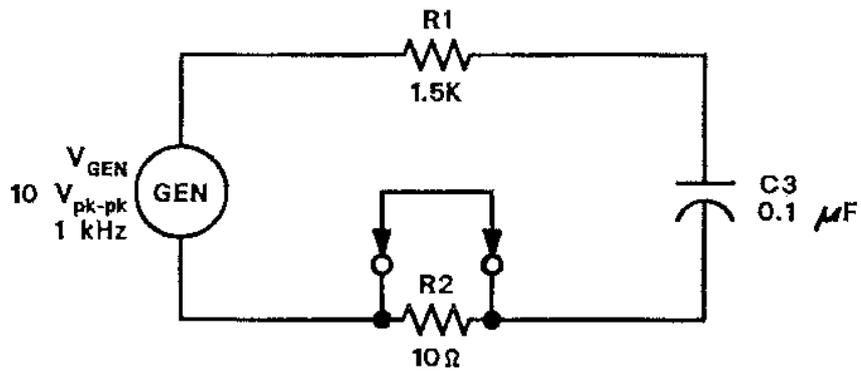


Figure 3 Capacitive reactance test circuit

Result:**Table 2**

No	Step	Description	Value/ Answer
1	2	X_{C3} (Calculated)	
2	3	Total circuit current (I) (Calculated)	
3	4	Voltage drop across capacitor C3 (V_{C3})	
4	5	Measured X_{C3} (Initial Measurement)	
5	5	Comparison of Step 2 and Step 5	
6	6	Calculated X_{C3} (Decreased Capacitance)	
7	7	Measured X_{C3} (Decreased Capacitance)	I: V_{C3} : X_{C3}
8	7	The change of capacitive resistance with decreasing capacitance	Discussion:
9	9	Measured X_{C3} (Decreased Frequency)	I: V_{C3} : X_{C3}
10	9	Comparison of Step 9 and Step 5	
11	9	The change of the capacitive reactance with decreasing frequency	Discussion:
12	10	Measured X_{C3} (Decreased Amplitude)	I: V_{C3} : X_{C3}
13	11	Observation on the change of X_{C3}	Reason/Discussion:



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**FUNDAMENTAL OF ELECTRICAL CIRCUIT
(SMJE 1023)**

2018/2019 – SEMESTER 1

**FUNDAMENTAL OF ELECTRICAL CIRCUITS
LABORATORY SHEET 4**

SERIES AND PARALLEL RLC CIRCUITS

TOPICS

1. SERIES RLC CIRCUIT
2. PARALLEL RLC CIRCUIT

OBJECTIVES:

1. To measure current, voltage, total impedance, and phase angle in a series and parallel RLC circuits
2. To observe and analyse voltage and current waveforms in series and parallel RLC circuits
3. To observe the circuit behaviour with the change of capacitance and frequencies

LIST OF INSTRUMENTS:

1. F.A.C.E.T Base Unit
2. Virtual Oscilloscope
3. Virtual Generator
4. AC 2 Fundamental Circuit Board
5. Multimeter

EXPERIMENT 1: SERIES RLC CIRCUIT

Objectives:

1. To measure current, voltage, and phase angle of a series RLC circuit
2. To observe voltage and current waveforms in a series RLC circuit
3. To observe the circuit behaviour with the change of frequencies

Procedure:

1. Insert the AC 2 FUNDAMENTALS circuit board into the base unit. Turn on the power source.
2. Locate the RLC/RESONANCE/POWER circuit block. Connect the circuit shown in Figure 1.
3. Adjust the sine wave generator frequency to 20 kHz and the voltage to 15 V_{p-p}.
4. Measure total circuit current (I_T), V_{R2} , V_{L1} and V_{C1} . Record your results in Table 1.
5. Observe the waveform of the generator (V_{GEN}) and total circuit current (I_T). **Sketch** the waveforms of V_{GEN} and I_T . Record the phase shift between V_{GEN} and I_T .
6. Adjust the generator frequency to 70 kHz.
7. Repeat Step 4 and 5.
8. Adjust the generator frequency to 20 kHz.
9. Varies the generator frequency until V_{GEN} and I_T are in phase. Record the frequency value in Table 1.
10. Measure I_T , V_{R2} , V_{L1} and V_{C1} . Record your results in Table 1.
11. Turn off the power source.

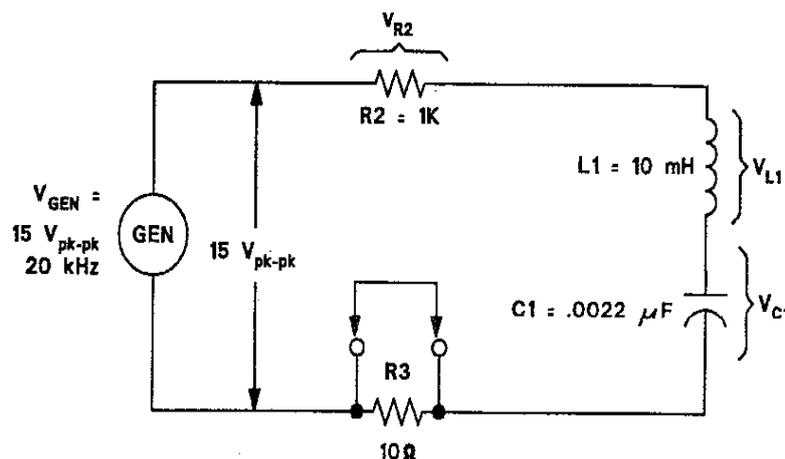


Figure 1 Series RLC Circuit

Result:**Table 1**

Step	Description	Measured Value			
		I_T	V_{R2}	V_{L1}	V_{C1}
4	$f = 20 \text{ kHz}$				
5	Phase shift between V_{GEN} and I_T				
7	$f = 70 \text{ kHz}$				
7	Phase shift between V_{GEN} and I_T				
9	V_{GEN} and I_T are in phase	<i>Frequency, $f =$</i>			
10	V_{GEN} and I_T are in phase				

Question (log book):

1. Discuss the effect of changing the frequency value on I_T , V_{C1} and V_{L1} (Step 4 and 7)
2. Discuss the effect of changing the frequency value on phase shift between V_{GEN} and I_T .
3. Compare the current obtained in Step 4, 7 and 10. Discuss why the current is at maximum when V_{GEN} and I_T are in phase.

Question (long report):

1. For each value of frequency, calculate I_T , V_{R2} , V_{L1} and V_{C1} . Compare with the measured values.
2. Compare the calculated values of phase shift between V_{GEN} and I_T with the measured values.
3. Draw the phasor diagram for the measured values obtained in Step 5 and 7.
4. Compare the measured values of V_{GEN} and V_{R2} when V_{GEN} and I_T are in phase. Discuss.
5. Compare the measured values of V_{L1} and V_{C1} when V_{GEN} and I_T are in phase. Discuss.
6. Calculate the frequency at which the reactance of inductor is equal to the reactance of capacitor ($X_L = X_C$). Compare with the measured value.
7. Discuss why the current is at maximum when $X_L = X_C$.

EXPERIMENT 2: PARALLEL RLC CIRCUIT

Objectives:

1. To measure current, voltage, and phase angle of a parallel RLC circuit.
2. To observe voltage and current waveforms in a parallel RLC circuit.
3. To observe the circuit behaviour with the change of frequencies

Procedure:

1. Connect the circuit shown in Figure 2. Turn on the power source.
2. Adjust the sine wave generator frequency to 20 kHz and the voltage to 15 V_{p-p}.
3. Measure I_T , I_{R6} , V_{R4} and V_{R5} . Record your results in Table 2.
4. Calculate I_{C2} and I_{L2} . Record your results in Table 2.
5. Observe the waveform of V_{GEN} and I_T . **Sketch** both waveforms. Record their phase shift.
6. Adjust the frequency of the generator to 50 kHz.
7. Repeat Step 3, 4, and 5.
8. Adjust the generator frequency to 20 kHz.
9. Varies the generator frequency until V_{GEN} and I_T are in phase. Record the frequency value in Table 2.
10. Measure I_T , I_{R6} , V_{R4} and V_{R5} . Record your results in Table 2.
11. Calculate I_{C2} and I_{L2} . Record your results in Table 2.
12. Turn off the power source.

Note: Current I_{C2} and I_{L2} , can be found by measuring the voltage across R4 and R5 respectively.

Figure 1 Series RLC Circuit

Result:**Table 2**

Step	Measured Value				Calculated Value	
	I_T	I_{R6}	V_{R4}	V_{R5}	I_{C2}	I_{L2}
3						
4						
5	Phase shift between V_{GEN} and I_T					
7						
7						
7	Phase shift between V_{GEN} and I_T					
9	Frequency when V_{GEN} and I_T are in phase					
10						
11						

Question (log book):

1. Discuss the effect of changing the frequency value on I_T , I_{R6} , I_{C2} and I_{L2} .
2. Discuss the effect of changing the frequency value on phase shift between V_{GEN} and I_T .
3. Compare the current I_T obtained in Step 3, 7 and 10. Discuss why the current is at minimum when V_{GEN} and I_T are in phase.

Question (long report):

1. For each value of frequency, calculate I_{L2} , I_{C2} , I_{R6} and I_T . Compare with the measured values.
2. Compare the calculated values of phase shift between V_{GEN} and I_T with the measured values.
3. Draw the phasor diagram for the measured values obtained in Step 5 and 7.
4. Compare the values of I_{L2} and I_{C2} when V_{GEN} and I_T are in phase. Discuss.
5. Calculate the frequency at which the reactance of inductor is equal to the reactance of capacitor ($X_L = X_C$). Compare with the measured value.
6. Discuss why the current is at minimum when $X_L = X_C$.



**MALAYSIA-JAPAN INTERNATIONAL INSTITUTE OF
TECHNOLOGY**

**ELECTRONIC ENGINEERING LABORATORY I
(SMJE 1062)**

2018/2019 – SEMESTER 1

FUNDAMENTAL OF ELECTRICAL CIRCUITS

LABORATORY SHEET 5

TOPICS

1. HIGH PASS FILTER

OBJECTIVES:

- To demonstrate the operation of RC and RL high pass filters
- To calculate and measure the cut-off frequencies and attenuation rates of RC and RL high pass filters
- To observe the relationship between cut-off frequencies and capacitance/inductance in RC and RL high pass filters

MATERIALS REQUIRED:

1. F.A.C.E.T Base Unit (Power Supply, 15 Vdc)
2. Virtual Oscilloscope
3. Virtual Generator
4. AC 2 Fundamental circuit board
5. HIGH PASS FILTER circuit block

EXPERIMENT 1: RC HIGH PASS FILTER

Procedure:

1. Insert the AC 2 FUNDAMENTALS circuit board into the base unit. Locate the HIGH PASS FILTER circuit block on the AC 2 FUNDAMENTALS circuit board. Connect the RC high pass circuit as shown in Figure 1. Turn on the power sources.
2. From the values given in Figure 1, calculate cut-off frequency, f_{CO} [$f_{CO} = 1/(2\pi RC)$]. Record the result in Table 1-1.
3. Set the generator for a 15 V_{pk-pk}, 100 kHz sine wave. Vary the generator frequency over the 100 kHz to 100 Hz range while observing the filter output voltage across R2 (V_{R2}). Repeat several times so that you can see how voltage changes with frequency. Write down your observation on the change of V_{R2} with a decrease in frequency in Table 1.
4. Complete Table 1 by adjusting the frequencies at the generator. Compute the dB values from the expression $\text{dB} = 20 \log (V_{R2} \text{ at } f / V_{R2} \text{ at } 100 \text{ kHz})$. Record the value in Table 1.
5. Calculate and record the output voltage level at the 3 dB down point. ($V_{-3\text{dB}} = V_{R2} \text{ at } 100 \text{ kHz} \times 0.707$).
6. By varying the frequency of the generator, adjust your filter output voltage to the V_{-3dB} value that was obtained in step 5. This is the value of cut-off frequency, f_{CO} . Complete the missing values in Graph 1.
7. Refer to Graph 1; determine the attenuation difference (in dB/decade) obtained between 500 Hz and 5 kHz. Record your answer in Table 1-2.
8. Repeat Step 3 to Step 7 by setting the CM switch 14 in the ON position to change the value of C1 to 0.005 μF . Prepare your own table and graph for your answer.
9. Turn CM switch 14 to the OFF position. Switch off the power source.

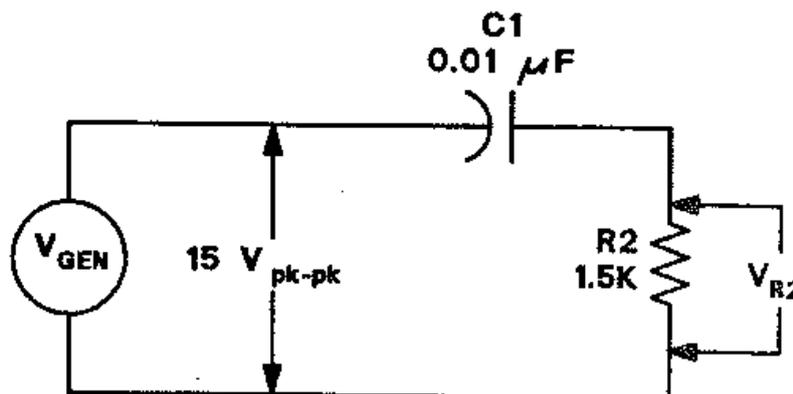


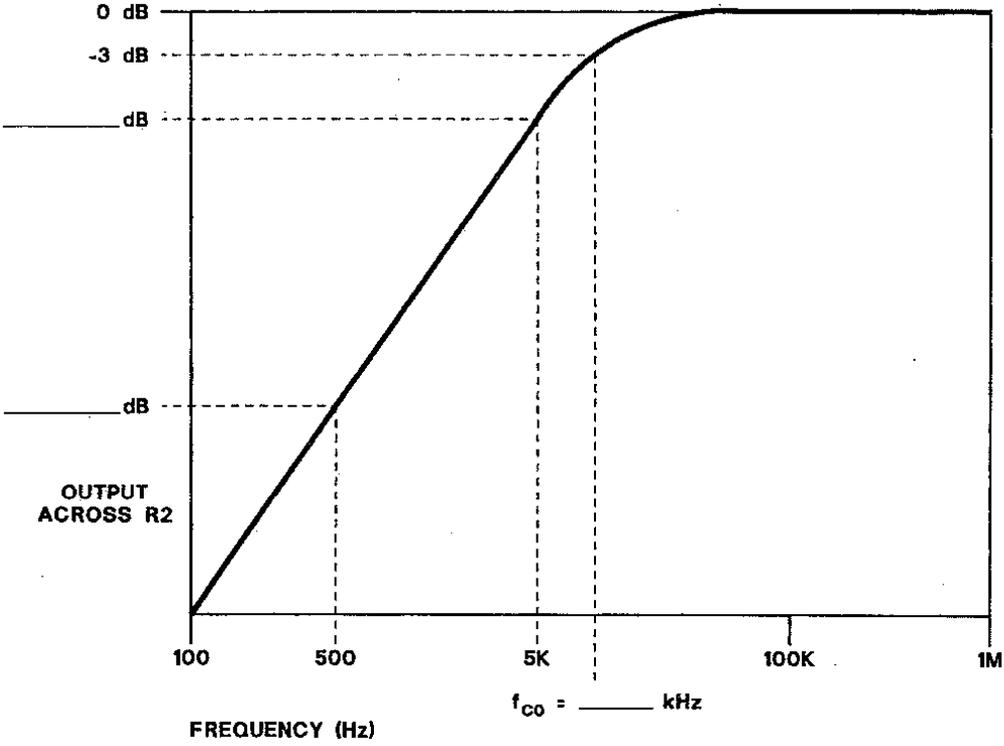
Figure 1: RC high pass filter

Results:

Table 1-1. Result for circuit with C = 0.01 μF

Step	Description	Value/Observation															
2	Calculated cut-off frequency, f_{CO} [$f_{CO} = 1/(2\pi RC)$]																
3	The change of V_{R2} with decreasing frequencies																
4	V_{R2} at each frequency	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="3" style="text-align: center;">Table 1</th> </tr> <tr> <th style="text-align: center;">FREQUENCY</th> <th style="text-align: center;">$V_{OUT} (V_{R2})$</th> <th style="text-align: center;">dB DOWN</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">100 kHz</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">5 kHz</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">500 Hz</td> <td></td> <td></td> </tr> </tbody> </table>	Table 1			FREQUENCY	$V_{OUT} (V_{R2})$	dB DOWN	100 kHz			5 kHz			500 Hz		
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FREQUENCY	$V_{OUT} (V_{R2})$	dB DOWN															
100 kHz																	
5 kHz																	
500 Hz																	
5	Output voltage level at the 3 dB down point. ($V_{-3dB} = V_{R2} \text{ at } 100 \text{ kHz} \times 0.707$)																

Table 1-2. Result for circuit with C = 0.01 μF

Step	Description	Value/Discussion
6	 <p style="text-align: center;">Graph 1 Response curve of an RC circuit</p>	
7	Attenuation difference (dB/decade):	

Discussion:

1. Compare the attenuation difference value obtained in the experiment with the theoretical value. Discuss.
2. What is the effect of changing the capacitor values in RC high pass filter circuit? Discuss.

EXPERIMENT 2: RL HIGH PASS FILTER

Procedure:

1. Locate the HIGH PASS FILTER circuit block on the AC 2 FUNDAMENTALS circuit board. Connect the RL high pass circuit as shown in Figure 2. Turn on the power sources.
2. From the values given in Figure 2, calculate f_{CO} [$f_{CO} = R / (2\pi L)$]. Record the result in Table 2-1.
3. Set the generator for a 15 V_{pk-pk}, 100 kHz sine wave. Vary the generator frequency over the 100 kHz to 1 kHz range while observing the filter output voltage across L1 (V_{L1}). Write down your observation in Table 2-1.
4. Calculate the output voltage level at the 3 dB down point (V_{-3dB} = V_{L1} at 100 kHz × 0.707). Record the value in Table 2-1.
5. By varying the frequency of the generator, adjust your filter output (V_{L1}) to the computed value of V_{-3dB} in Step 4. Measure the output period of the generator. Convert this value to frequency to get f_{CO} and record the value in Table 2-1.
6. By using the f_{CO} measured value in step 5, determine in dB the amount of attenuation (loss) of a frequency one octave lower than the cut-off frequency (f_{CO}). Record the value in Table 2-1.
7. Repeat Step 2 to Step 6 by setting the CM switch 15 in the ON position to change the value of L1 to 20 mH. Prepare your own table and graph for your answer.
8. Turn CM switch 15 to the OFF position. Switch off the power source.

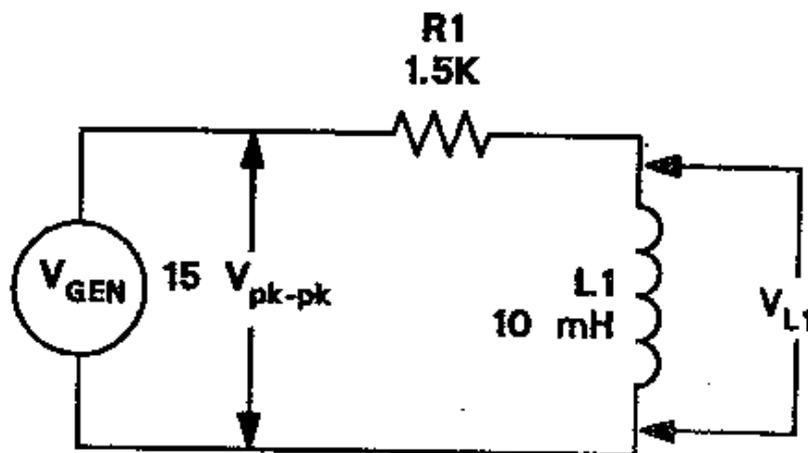


Figure 2: RL high pass filter

Results:**Table 2-1. Result for circuit with L = 10 mH**

Step	Description	Value/Observation
2	Calculated cut-off frequency, f_{CO} [$f_{CO} = R/(2\pi L)$]	
3	The change of V_{L1} with decreasing frequencies	
4	Output voltage level at the 3 dB down point ($V_{-3dB} = V_{L1}$ at $100 \text{ kHz} \times 0.707$)	
5	Cut-off frequency, f_{CO}	Output period: Cut-off frequency:
6	The amount of attenuation of a frequency that is one octave lower than the cut-off frequency.	dB

Discussion:

1. Compare the attenuation difference value obtained in the experiment with the theoretical value. Discuss.
2. What is the effect of changing the inductor in RL high pass filter circuit? Discuss.
3. What is the difference between using the RC high pass filter and the RL high pass filter?