Experiment 5, Current in a Parallel Resonant Circuit,

For more courses visit www.cie-wc.edu
OBJECTIVES:

1. To verify by experiment, that the line current \( (I_{\text{line}}) \) is at its minimum value when the circuit is at resonance.

2. To demonstrate that the circulating current \( (I_{\text{tank}}) \) is greater than the line current \( (I_{\text{line}}) \) when the circuit is at resonance.
You will recall from Experiment 4 that the **impedance** of a parallel LC circuit reaches its **maximum** value when the circuit is at resonance.

If the **impedance** is at its **maximum** value and the applied voltage is constant over the frequency band, then the **current** will be at its **minimum** value ($I_{\text{line}} = E/Z_0$).
The current circulating between the parallel components (L and C) is usually many times greater than the line current. This circulating current ($I_{tank}$) is the applied voltage (E) divided by the reactance of either the capacitor or inductor.
The reactive currents are high, but 180° out of phase with each other ($I_C$ and $I_L$) and will cancel out. (Theoretically, the currents would cancel each other out except for the presence of resistance in the coil.)

The following couple slides illustrate an example which shows the above relationship of the components.
RELATIONSHIP OF $I_{\text{line}}$ & $I_{\text{tank}}$ CIRCUIT

![Circuit Diagram]

- $E$: 10V
- $C$: 0.01$\mu$F
- $L$: 50mH
- $R_1$: 50$\Omega$
- $I_{\text{line}}$
- Circulating Current
- $I_c$
- $I_L$
\[ f_0 = \frac{1}{2\pi \sqrt{LC}} = 7121 \text{ Hz} \]

\[ X_L = 2\pi f L = 2236 \Omega \]

\[ Q = \frac{X_L}{R} = 45 \]

\[ Z_0 = QX_L = 100,600 \Omega \]

\[ I_{\text{line}} = \frac{E}{Z_0} = 0.1 \text{ mA} \]

\[ I_{\text{tank}} = I_C = I_L = \frac{E}{X_L} = 4.5 \text{ mA} \]

\[ \frac{I_{\text{tank}}}{I_{\text{line}}} = \frac{.0045}{.0001} = 45:1 \]
The ratio between $I_{\text{tank}} / I_{\text{line}}$ reflects the differences between the two values. Theoretically, the ratio is 45:1, but in practice; when circuit conditions are taken into account, this ratio may be as low as 5:1. The ratio can be reduced even further, the larger the internal resistance of the conductor.
PARTS REQUIRED

1 107mH ferrite coil
1 0.01 µF disc capacitor (103)
1 470 Ω ½ Watt resistor (yellow/violet/brown)
1 3.3k Ω resistor (orange/orange/red)
1 1000 µF electrolytic capacitor
PROCEDURE

Note: Please take your time when making voltage and resistance measurements: accuracy is very important to the success of this experiment.

1. Construct the next circuit shown using the following components: \( C = 0.01 \, \mu F, \ L = 107 \, mH, \) and \( R_1 = 3300\Omega. \)
2. Turn the trainer on and set the generator range switch to X10.
   a) Rotate the FREQ knob to its maximum CCW position
3. Set your meter on the 10 V AC scale and connect it across $R_1$. 
4. Turn the FREQ knob until you see a dip or null in the voltage across \( R_1 (E_{R1}) \).
   
a) Mark the resonant frequency point on the calibration dial, using a soft lead pencil.
   
b) Measure the voltage drop across \( R_1 (E_{R1}) \).
   
1. Record the value in the Exp. 5 data table
   
c) Estimate the resonant frequency
   
1. Record the value in the Exp. 5 data table
<table>
<thead>
<tr>
<th>Step #</th>
<th>Description</th>
<th>Measured Values</th>
<th>Calculated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>$E_{R1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Calculated Resonant Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>$E_{RL}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Resistor $R_i$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Resistor $R_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Calculate $I_{line}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Calculate $I_{tank}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Ratio of $I_{tank}$ to $I_{line}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Measure the voltage across $R_L (E_{RL})$.
   a) Record the value in the Exp. 5 data table

6. Turn off the trainer and remove resistors $R_L$ and $R_1$.
   a) Measure the resistor values and record the values in the Exp. 5 data table
7. Calculate the line current using the formula $E_{R1}/R_1$.
   a) Record the value in the Exp. 5 data table

8. Calculate the tank current using the formula $E_{RL}/R_L$.
   a) Record the value in the Exp. 5 data table
5. Compare the tank and the line currents by taking the ratio $I_{tank}/I_{line}$.

a) Record the ratio in the Exp. 5 data table. (The tank current should be greater than the value of the line current.)
CIE RESULTS

- The data obtained by CIE is listed in the Experiment 5 data table results, on the next slide.

- The estimated resonant frequency was the same as was found in Experiment 4 (426 mA), as compared to the $I_{\text{line}}$ which was calculated as 60 mA.

- The ratio between $I_{\text{tank}}$ and $I_{\text{line}}$ was determined as 7.03:1, which is within the acceptable range of results.
## EXPERIMENT 5 DATA TABLE RESULTS

<table>
<thead>
<tr>
<th>Step #</th>
<th>Description</th>
<th>Measured Values</th>
<th>Calculated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>$E_{R_1}$</td>
<td>0.2 V</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Calculated Resonant Frequency</td>
<td>5000 Hz</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>$E_{RL}$</td>
<td>0.2 V</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Resistor $R_L$</td>
<td>470 $\Omega$</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Resistor $R_1$</td>
<td>3300 $\Omega$</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Calculate $I_{line}$</td>
<td></td>
<td>60.6 $\mu$A</td>
</tr>
<tr>
<td>8.</td>
<td>Calculate $I_{tank}$</td>
<td></td>
<td>426 $\mu$A</td>
</tr>
<tr>
<td>9.</td>
<td>Ratio of $I_{tank}$ to $I_{line}$</td>
<td></td>
<td>7.03:1</td>
</tr>
</tbody>
</table>
We have found in a parallel resonant circuit which is at resonance, the impedance is at its maximum value and the $I_{\text{line}}$ is at its minimum value.

This condition is obvious, since the resonant point is determined by a dip in the voltage drop across $R_1$.

This dip is due to the high impedance occurring as the circuit reaches its resonant point.
The values obtained ($I_{\text{tank}} = 426 \text{ mA}; I_{\text{line}} = 60.6 \text{ mA}$) give a clear indication that, at resonance, the tank current is greater than the line current.

In this experiment, the ratio between tank current and line current was 7.03:1.
QUESTIONS?
Developed and Produced by the Instructors in the CIE Instruction Department.

© Copyright 08/2012

All Rights Reserved /August 2012