LCR RESONANCE CURVE ON CRT

Resonance in an LCR circuit is demonstrated by displaying the voltage across the resistor as a function of driving frequency.

Equipment:
- Tek 465 Oscilloscope
- HP 3310A Function Generator
- HP 3312A Function Generator
- General Radio Decade Capacitor (MIT# 15901-0082)
- GR Inductor, 10mH/step
- Resistor Box with Switch, Lab-Made
- 6 BNC Cables, 1 Banana Cable and 4 BNC-To-Banana Connectors
Swept Display of RLC Resonance

Parts List:

1. Hewlett Packard 3312A signal generator
2. 5 BNC cables, 1 M
3. GenRad decade capacitor
4. Step inductor
5. Variable resistor assembly housed in minibox. (specific to this demo)
6. Tektronix 533 scope with type E plug in.

Assembly

1. Connect L and C in series to output of signal generator using BNC cables. Use banana adaptors as necessary.
2. The variable resistor, diode and the fixed resistors are all part of one assembly that is housed in a minibox. Connect box to the inductor and to the scope vertical input using BNC cables.
3. Connect MOD OUT of the signal generator to the X-axis input of the scope.
4. Set the signal generator for 2-3 KHz sine wave output, Frequency sweep in sine wave form. Set modulation range to 100Hz and the output level to about 1 V.
5. Set the scope for external horizontal input.
6. Power up scope and signal generator. Observe scope while tuning the frequency output of the signal generator so that a peak can be seen in the center of the screen.
7. Adjust the modulation symmetry, modulation range and frequency for desired waveform.
X8I. Resonance Curves in Driven LRC Circuit Created on CRT - 10W

*Purpose:* Illustrate in a stepwise manner the meaning of 'resonance curves' (amplitude vs freq.) in a driven LRC circuit. Show change of shape and position of resonance peak as circuit parameters are varied.

*Equipment:* LRC circuit (L and C are variable; L ~ 50 mH, C ~ 0.4 μF; R may be intrinsic??); oscillator; CRT projected.

*Procedure:*
- Resonance curve constructed step-by-step (see sketches)
- Ampl. of oscillations on vertical sweep; horizontal is time or freq.
- Change L and C, note peak moves with freq, also width changes.
- Resonance frequency is 1.1 kHz for values given above (see below).
- In cases (a) - (c), oscillator output frequency is changed by hand. One should also drive frequency very slowly and cyclically at ~ 1 Hz (sinusoidally?), with the scope driving the oscillator frequency.
  - (a) no horizontal sweep; change freq. by hand; see vertical line changing length;
    - Amplitude goes up and down as driving freq changes.
    - Drive it with scope at ~ 1 Hz (optional); see same effect.
  - (b) horiz. sweep = time: see sine waves; change freq by hand;
    - See wavelength and amplitude of sine waves change
    - Drive at ~ 1 Hz with scope; see same effect but cyclic.
  - (c) Horizontal sweep is driving frequency: Adjust freq by hand
    - Show 3 different frequencies; Note 3 different ampl.
    - Drive at ~ 1 Hz with scope
  - (d) Horizontal sweep is still driving frequency
    - Drive horiz. sweep at higher repetition rate (50 - 100 Hz?) by increasing scope sweep frequency.
    - See entire resonance curve
    - Resonant frequency of circuit (~ 1 kHz) is higher than sweep freq. so see 10 or so cycles in resonance peak.
  - (e) Change L and C and note resonance and width changes
    - Start with L = 50 mH and C = 0.4 μF; \( \omega_0 = 1.1 \text{ kHz} \)
    - Change L to 60 mH: \( \omega_0 \) decreases
    - Change C to 0.3 μF: \( \omega_0 \) increases to about 1.1 kHz
    - Note: width of curve changes: \( \Delta \omega/\omega = R/\omega L \)
    - *NOTE THIS EXPERIMENT WAS VERY FLAKY IN 1986; FINE IN 1987*
    - High impedance input; preamp on scope must be discharged now and then (push button)
    - *Very likely transmitter microphone was interfering!*
    - 1987: it was OK; forget what we did; I think we were using different preamp.
    - 1987: did not do quantitative calculation (or abbreviated it).


SEE SKETCHES NEXT PAGE
Swept Frequency Range as a Function of VCO Input Voltage

<table>
<thead>
<tr>
<th>Input Voltage (4.2 Vp-p)</th>
<th>Output Frequency (3312 A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.1 V</td>
<td>9.6 Hz</td>
</tr>
<tr>
<td>-1.5 V</td>
<td>161 Hz</td>
</tr>
<tr>
<td>-1.0 V</td>
<td>500 Hz</td>
</tr>
<tr>
<td>-0.5 V</td>
<td>837 Hz</td>
</tr>
<tr>
<td>0 V</td>
<td>1.17 kHz</td>
</tr>
<tr>
<td>+0.5 V</td>
<td>1.516 kHz</td>
</tr>
<tr>
<td>+1.0 V</td>
<td>1.856 kHz</td>
</tr>
<tr>
<td>+1.5 V</td>
<td>2.182 kHz</td>
</tr>
<tr>
<td>+2.1 V</td>
<td>2.600 kHz</td>
</tr>
</tbody>
</table>
SET UP:

WIRE THE SERIES LCR CIRCUIT AS ABOVE. THE 3312A OUTPUT DRIVES THE CAPACITOR. THE HI OUTPUT OF THE 3310A IS T'ED OFF TO THE VCC CONNECTOR AT THE BACK OF THE 3312A AND TO SCOPE CH1. SET THE RESISTOR SWITCH TO SHORT.

3310A: RANGE = .1
       DIAL = 5
       DC OFFSET = 0
       FUNCTION = SINE

3312A: MAKE SURE AM, FM, SWP ARE NOT DEPRESSED.
       RANGE = 1K
       DIAL = 1.1 (APPROX)
       FUNCTION = SINE ( ~ )
       OFFSET IS CENTERED
       AMPLITUDE = 10 , ADJUST VERNIER LATER

CAPACITOR:
       C = .3 MICRO F

INDUCTOR:
       L = 60 MILLI H

OSCILLOSCOPE:
       TIME/DIV SET TO XY
       TRIGGER SOURCE = CH2
       VERT MODE = CH2 (XY)
       CH1: SELECT GND, 0.2 V/DIV
       CH2: SELECT DC, 50 MILLI VOLTS/DIV

(a)

NOW THERE IS NO HORIZONTAL SWEEP, THE DISPLAY ( PROPERLY CENTERED ) SHOULD SHOW A LINE OSCILLATING IN LENGTH.
SWITCH 3310A RANGE TO .0001
SET TIME/DIV TO .5 MILLISEC ON SCOPE
SHOULD SEE SINE WAVES. ADJUST FREQUENCY WITH 3310A DC OFFSET.

Below Resonance

Resonance

Above Resonance

(This step can also be accomplished by disconnecting the 'T' from the 3310A and adjusting the frequency on the 3312A.)
SELECT DC FOR CH1 ON SCOPE
SET TIME/DIV BACK TO XY
HORIZONTAL AXIS IS NOW FREQUENCY (REALLY IT IS THE MODULATING VOLTAGE WHICH DRIVES THE FREQUENCY AROUND THE CENTRAL FREQUENCY SET ON THE 3312A, THIS CENTRAL FREQUENCY SHOULD BE THE RESONANCE FREQUENCY).

SINCE THE 3310A RANGE IS .0001, THE 3312A FREQUENCY IS ESSENTIALLY CONSTANT. ADJUST THE 3312A FREQUENCY BY CHANGING THE 3310A DC OFFSET. SEE PHOTO BELOW.

(d) SET 3310A DC OFFSET BACK TO 0
SET 3310A RANGE TO .1
FREQUENCY IS NOW SWEPT THROUGH RESONANCE, SEE
(e) CHANGING L AND C.

- For L = 100 mH and C = 0.3 mF:

- For L = 60 mH and C = 0.2 mF:
MODES of OPERATION:

a) CH1: Select **GND** (no Horizontal Sweep)
   
   *see VERT line oscillating in length*

b) Disconnect "T" form HP 3310A
   - Change frequency of HP 3312A manually
   *obtain same effect as above (a)*

c) Keep HP3310A disconnected.
   - Change Time/Div. to **0.5ms**
   *Horizontal axis is time, get sine wave*
   - Change frequency of HP3312A manually
   *sweep passes through resonance*

d) Reconnect HP3310A
   - Keep CH1 **GND** selected
   - Keep Time/Div. to **0.5ms**
   *Obtain same effect as 9c), except Hp3310A drives sine wave back and forth through resonance*

e) Change Time/Div. **x-y** mode
   - Select **DC** on CH1
   *Horizontal axis is driving frequency swept automatically*
Scope traces: (a):

(changes length as driving freq. changed by hand.)

(b)  

Show as an aside (the usual view)

(c)

Follows directly from part (a)
3 frequencies set by hand sequentially

(d)

frequency swept automatically; envelope is resonance curve (with reflection)