

Wein-bridge oscillator

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For the Wein-bridge oscillator of Fig 0, use the expression for loop gain in (??) to find the poles of the closed-loop system. Give the expression for the pole, Q and use it to show that to locate the poles in the right half of s plane, $\frac{R_2}{R_1}$ must be selected to be greater than 2.

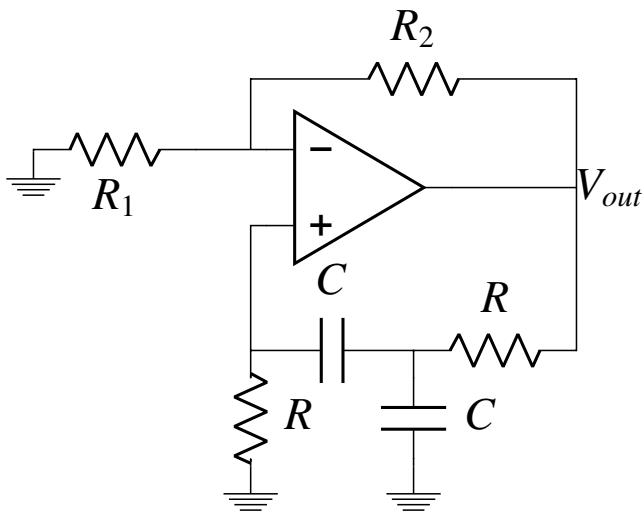


Fig. 0

- 1.
2. Compare the basic structure for a sinusoidal oscillator with Wein-bridge oscillator and give expressions for G and H.

Solution:

- Comparing Fig 0 and Fig 2, we get

$$G = 1 + \frac{R_2}{R_1} \quad (2.1)$$

$$H = \frac{Z_p}{Z_p + Z_s} \quad (2.2)$$

where,

$$Z_p = \frac{R}{sRC + 1} \quad (2.3)$$

$$Z_s = \frac{R}{sRC + 1} \quad (2.4)$$

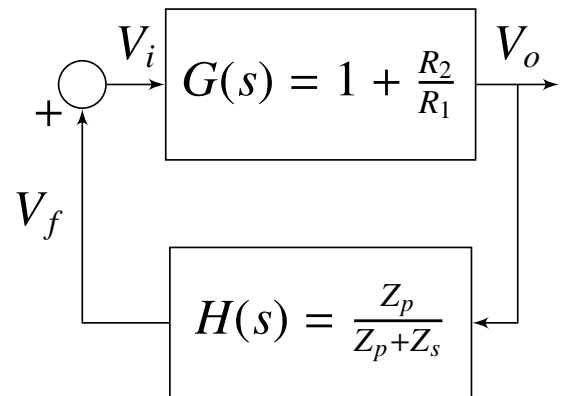


Fig. 2

3. Write the characteristic equation for Wein-bridge oscillator.

Solution:

$$1 - L(s) = 0 \quad (3.1)$$

$$1 - \frac{1 + \frac{R_2}{R_1}}{3 + sCR + \frac{1}{sCR}} = 0 \quad (3.2)$$

$$3 + sRC + \frac{1}{sCR} = 1 + \frac{R_2}{R_1} \quad (3.3)$$

$$3 - 1 + sRC + \frac{1}{sCR} - \frac{R_2}{R_1} = 0 \quad (3.4)$$

$$2s + s^2RC + \frac{1}{RC} - s\frac{R_2}{R_1} = 0 \quad (3.5)$$

$$s^2RC + s(2 - \frac{R_2}{R_1}) + \frac{1}{RC} = 0 \quad (3.6)$$

$$s^2 + s\frac{1}{RC}(2 - \frac{R_2}{R_1}) + \frac{1}{R^2C^2} = 0 \quad (3.7)$$

4. Write the general expression for the characteristic equation.

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Solution:

$$s^2 + s\frac{\omega_0}{Q} + \omega_0^2 = 0 \quad (4.1)$$

5. State the **Barkhausen criterion** for sustained oscillations with frequency ω_0 .

Solution:

$$L(j\omega_0) = G(j\omega_0)H(j\omega_0) = 1 \quad (5.1)$$

- That is, at ω_0 the phase of the loop gain should be zero and the magnitude of loop gain should be 1.
 - Only for a ∞ gain, system will produce a finite output for zero input.
6. Give the definition of **Quality factor(Q)** and explain its significance.

Solution:

- It is a parameter of an oscillatory system expressing the relationship between stored energy and energy dissipation.
 - The "purity" of output sine waves will be a function of the selectivity feedback network.
 - That is, higher the value of Q for frequency selective network, the less the harmonic content of sine wave produced.
7. Compare the equations 3.7 and 4.1 and give expressions for Q and ω_0

Solution:

$$\omega_0^2 = \frac{1}{R^2 C^2} \quad (7.1)$$

$$\omega_0 = \frac{1}{RC} \quad (7.2)$$

$$\frac{\omega_0}{Q} = \frac{1}{RC} \left(2 - \frac{R_2}{R_1}\right) \quad (7.3)$$

$$Q = \frac{1}{\left(2 - \frac{R_2}{R_1}\right)} \quad (7.4)$$

$$(7.5)$$

8. Using Eq 7.4 calculate the value of $\frac{R_2}{R_1}$ for which poles lie on right hand of s-plane.

Solution:

Poles lie on imaginary axis for $Q = \infty$

$$2 - \frac{R_2}{R_1} = 0 \quad (8.1)$$

$$\frac{R_2}{R_1} = 2 \quad (8.2)$$

\therefore For poles to lie on right hand side of s-plane

$$\frac{R_2}{R_1} > 2 \quad (8.3)$$

9. Verify the above calculations using a Python code.

Solution:

codes/ee18btech11044_3_1.py

- This figure shows how the location of poles vary if $\frac{R_2}{R_1}$ is varied for a fixed ω_0 .
- I have varied $\frac{R_2}{R_1}$ from -10 to 10.

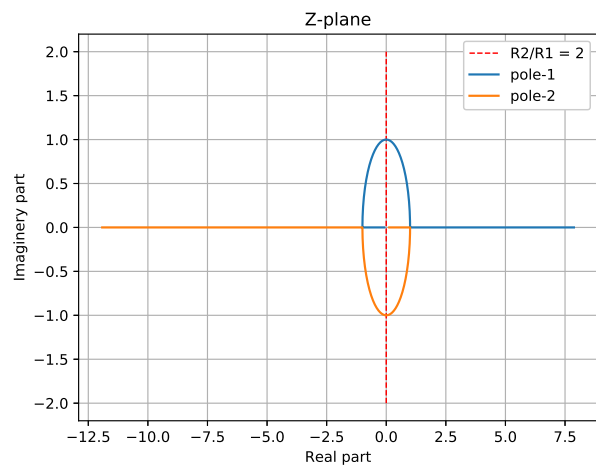


Fig. 9

10. Simulate the circuit shown in Fig 0 using spice simulators. Plot the output generated using python.

Solution:

You can find the netlist for the simulated circuit here:

spice/ee18btech11044/ee18btech11044.net

You can find the python script used to generate the output here:

spice/ee18btech11044/ee18btech11044_spice.py

11. Tabulate the values of Resistors and Capacitors you have chosen for the simulation.

Solution:

Where, according to Fig 0

$$R_p = R_s = R \quad (11.1)$$

$$C_p = C_s = C \quad (11.2)$$

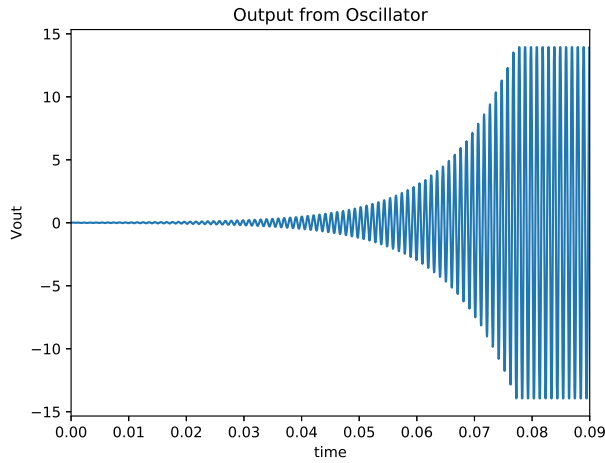


Fig. 10

Parameter	Value
R_1	$10k\Omega$
R_2	$20.3k\Omega$
R_p	$10k\Omega$
R_s	$10k\Omega$
C_s	$16nF$
R_p	$10k\Omega$
C_p	$16nF$

TABLE 11

12. Calculate the frequency of sinusoidal generated for the combination of R and C chosen using Eq 7.2

Solution:

Frequency generated is given by

$$\omega_0 = \frac{1}{RC} \quad (12.1)$$

$$\omega_0 = 6250 \text{ rad/sec} \quad (12.2)$$

$$f_0 = 995.22 \text{ Hz.} \quad (12.3)$$

13. Calculate the frequency of sinusoidal wave using plot generated from simulation.

Solution:

- Consider a part of plot generated from simulation shown in the Fig 13.
- Calculating the Time-period of the sinusoidal wave generated using the two points

marked in the Fig 13.

$$T_0 = 0.0856452 - 0.0846361 \quad (13.1)$$

$$f_0 = 1/T_0 \quad (13.2)$$

$$f_0 = 990.98 \text{ Hz.} \quad (13.3)$$

- We get the frequencies calculated from the formulae and the plot to be approximately same.
- Use this script to generate Fig 13

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spice/ee18btech11044/
ee18btech11044_spice_2.py
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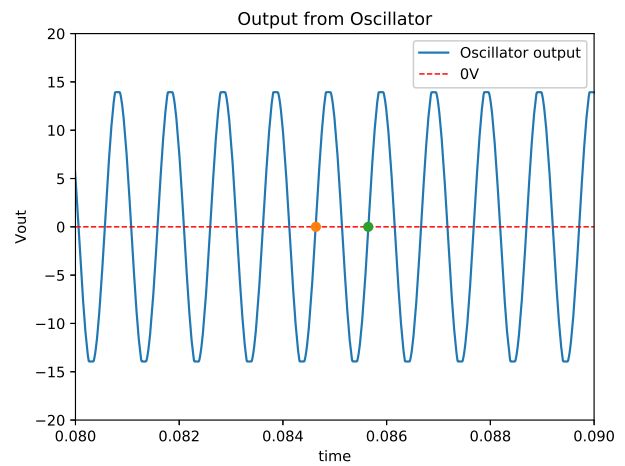


Fig. 13