EE203 - Electrical Circuits Laboratory

Experiment - 9 Simulation
Feedback Circuits

Objectives

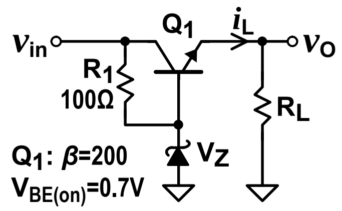
1. Observe operation of simple voltage regulator and oscillator circuits with feedback configurations.

Preliminary Work

1. Consider the voltage regulator on the right.

1.a) Describe the feedback mechanism of the regulator. What happens if v_O drops?

1.b) Determine the zener voltage $\mathbf{V_Z}$ to obtain **4 V DC** output.

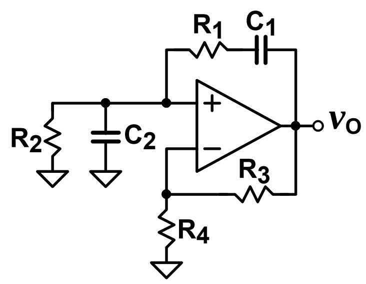


2. Consider the **Wien bridge oscillator** on the right.

2.a) Express the oscillation frequency in terms of circuit parameters.

2.b) Determine $\mathbf{R_1}$ and $\mathbf{R_2}$ to obtain **16 kHz** oscillation frequency when $\mathbf{C_1 = C_2 = 1}$ **nF**.

2.c) Describe the oscillation criterion and determine $\mathbf{R_3}$ accordingly when $\mathbf{R_4 = 10}$ **kΩ**.

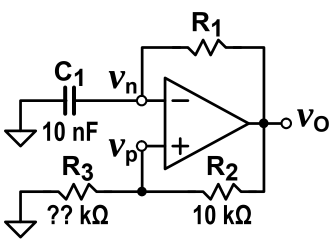


3. Consider the **Schmitt trigger oscillator** on the right.

3.a) Determine the value of $\mathbf{R_3}$ to obtain **4 Vp-p** amplitude at v_n. Assume that v_O changes between **-9 V** and **+9 V** in your calculation.

3.b) Determine the value of $\mathbf{R_1}$ to obtain **1 kHz** oscillation frequency.

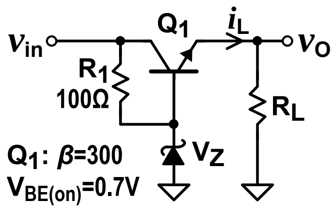
Hint: Express period of the oscillation waveform at v_n in terms of the $\tau = \mathbf{R_1C_1}$ time constant and the peak values of v_n and v_O.



Procedure

AD795 operational amplifier model will be used instead of **LM741** to obtain the simulation results on LTspice. Although **AD795** has much better characteristics compared to **LM741**, both of the devices satisfy the basic requirements of an operational amplifier. You should keep in mind that **AD795** has much higher output slew rate compared to **LM741** and this significantly changes the high-frequency response.

1. Build the voltage regulator circuit given on the right using **BC547B** transistor as **Q1**. Connect a **10 kΩ** resistor in place of R_L.

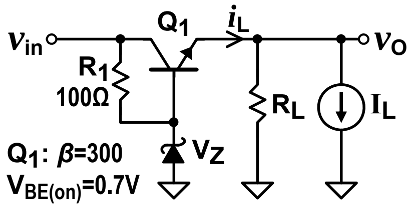


1.1 Determine line regulation when middle value of v_{in} is V_{inDC} **= 6.0 V**. Set v_{in} source to obtain **1 kHz 1 Vp-p** sinusoidal voltage with **6.0 V** DC offset and measure peak-to-peak AC component of v_O. Repeat line regulation measurement when V_{inDC} is **8.0 V**.

V_{inDC} value of v_{in} (V)	AC component of v_O (Vp-p)	**line regulation (V/V)**
6.0		
8.0		

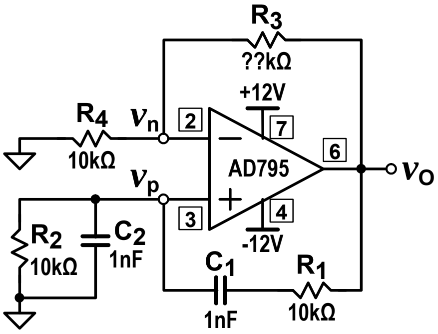
1.2 Determine load regulation when i_L increases by **100 mA** for v_{in} **= 6.0V** and v_{in} **= 8.0V**.

It is possible to measure load regulation and line regulation in the same simulation run. Add a **100 mA** pulsed current source I_L as an active load as shown on the right. Set simulation time to **10 ms** and turn on the I_L pulse at **5 ms**. Measure the step change in v_O when I_L turns on.



V_{inDC} value of v_{in} (V)	v_O (V) measured for i_L **= 0.4 mA**	v_O (V) measured for i_L **= 100 mA**	**load regulation (mV/mA)**
6.0			
8.0			

2. Build the **Wien bridge oscillator** given on the right. Set the opamp DC supplies to **+12 V** and **–12 V**.

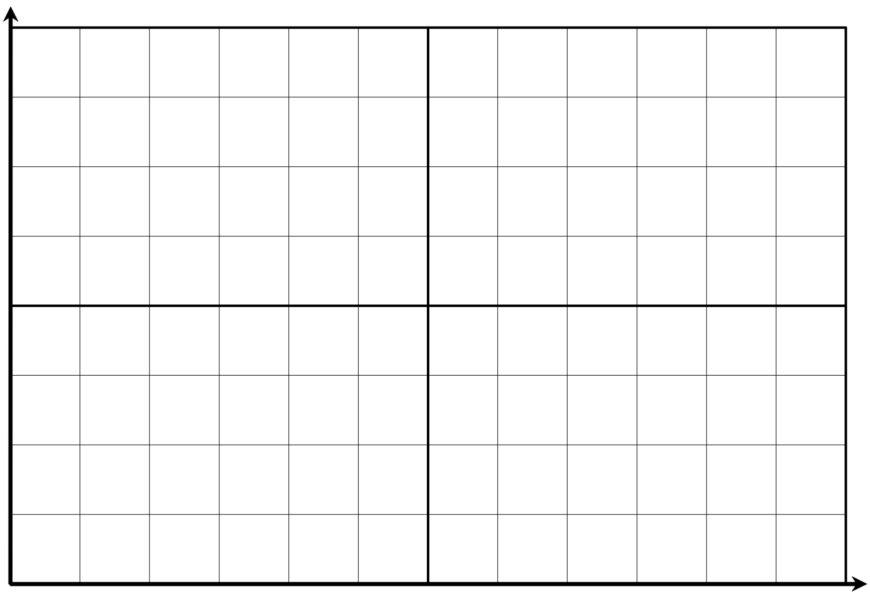


2.1 Find the lowest **R_3** value that enables oscillations. First change **R_3** in **10 kΩ** steps and then reduce step size to **1 kΩ**. Set simulation time to **20 ms** since it may take several milliseconds to start the oscillations.

R_3 = ___________

Does this result agree with your **R_3** prediction in the preliminary work?

2.2 Plot v_n, v_p and v_O waveforms below. Indicate units of amplitude and time axes on your plot. Measure and record the peak-to-peak output voltages and the oscillation frequency.

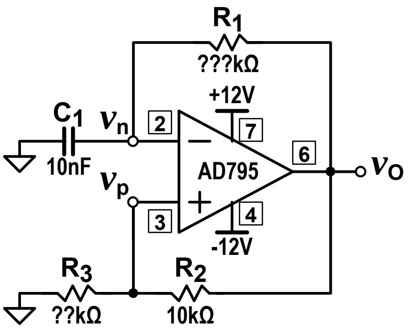


v_n : _________ v_p : _________ v_O : _________ **F_{osc} =** _________

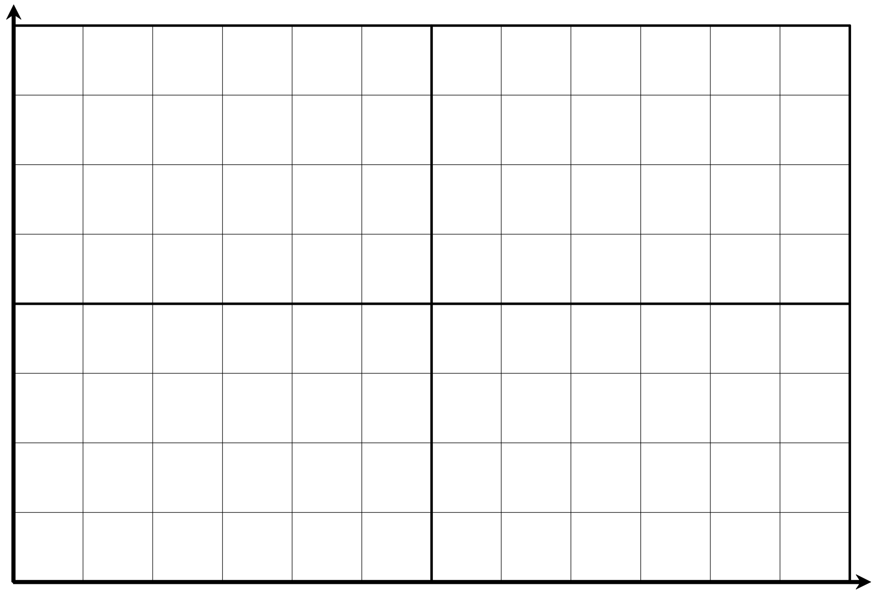
2.3 Measure the oscillation frequency obtained with the **R_2** resistance values listed in the following table. How does **R_2** affect the oscillation frequency?

R_2 (kΩ)	**F_{osc} (Hz)**
10	
20	
30	
40	

3. Build the **Schmitt trigger oscillator** circuit given on the right. Use a standard resistor value closest to the $\mathbf{R_3}$ calculated in the preliminary work.



3.1 Adjust $\mathbf{R_1}$ to obtain **1 kHz** oscillation frequency at v_O. Plot v_n, v_p and v_O waveforms below indicating all critical amplitude and timing information. Compare your measurements with the results obtained in the preliminary work.



Questions

Q1. List the steps in designing a Wien bridge oscillator.

Q2. List the steps in designing a Schmitt trigger oscillator.

Q3. Modify the circuit used in step-3 so that the opamp works with a single positive supply without significant change in the oscillation frequency.

Hint: Input waveforms should be centered around half the positive supply voltage. There is no DC level control on the negative opamp input. DC level of the positive opamp input depends on where $\mathbf{R_3}$ is connected to.