BENHA UNIVERSITY
FACULTY OF ENGINEERING AT SHOUBRA

ECE-312
Electronic Circuits (A)

Lecture # 11
Oscillators (RC Circuits)

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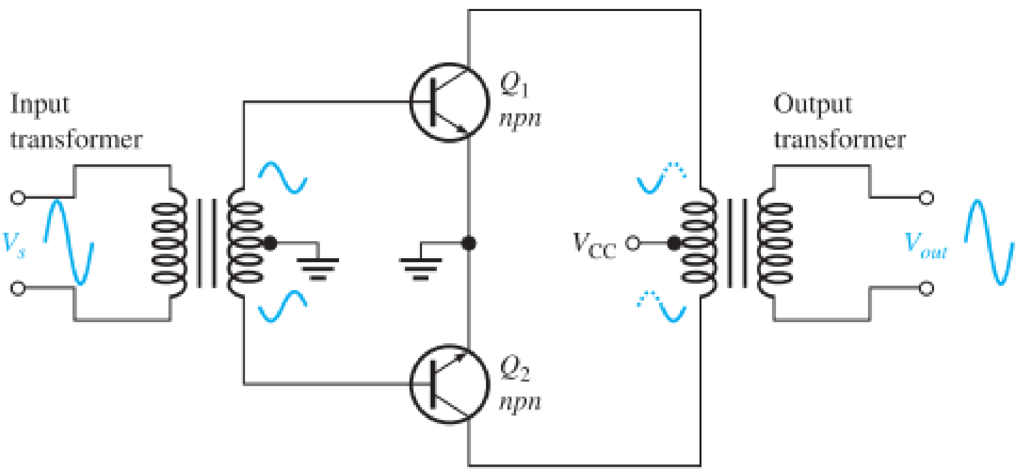
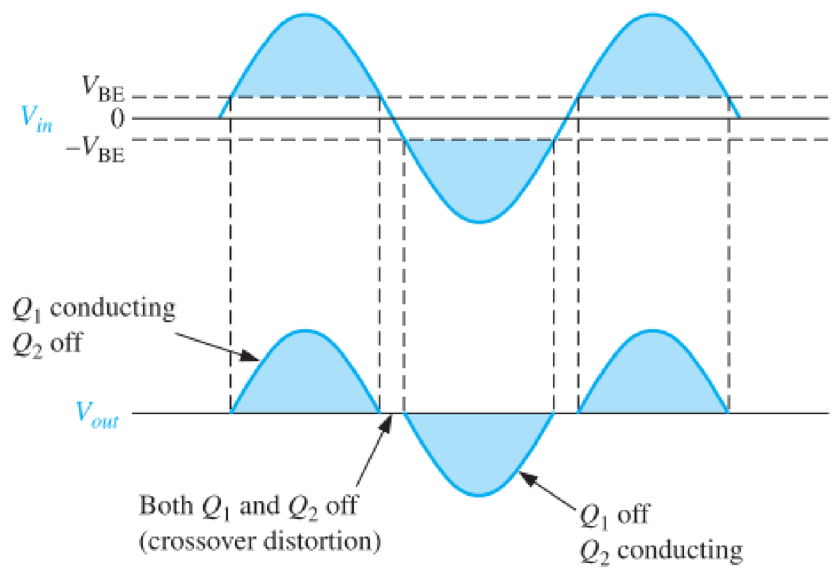
Agenda

- Introduction
- Feedback Oscillators
- Oscillators with RC Feedback Circuits

Crossover distortion in a class B push-pull amplifier



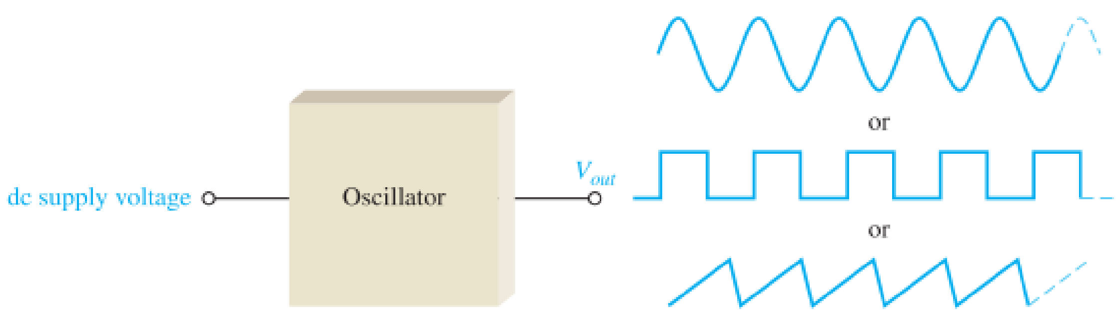


INTRODUCTION

Introduction

- An **oscillator** is a circuit that produces a periodic waveform on its output with only the dc supply voltage as an input.
- The output voltage can be either **sinusoidal** or **non sinusoidal**, depending on the type of oscillator.
- Two major classifications for oscillators are **feedback** oscillators and **relaxation** oscillators.

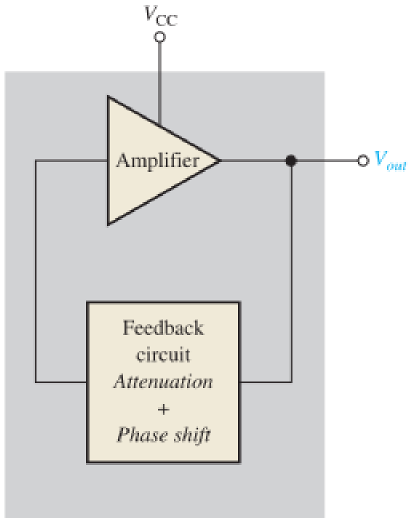
- an oscillator converts electrical energy from the dc power supply to periodic waveforms.



FEEDBACK OSCILLATORS

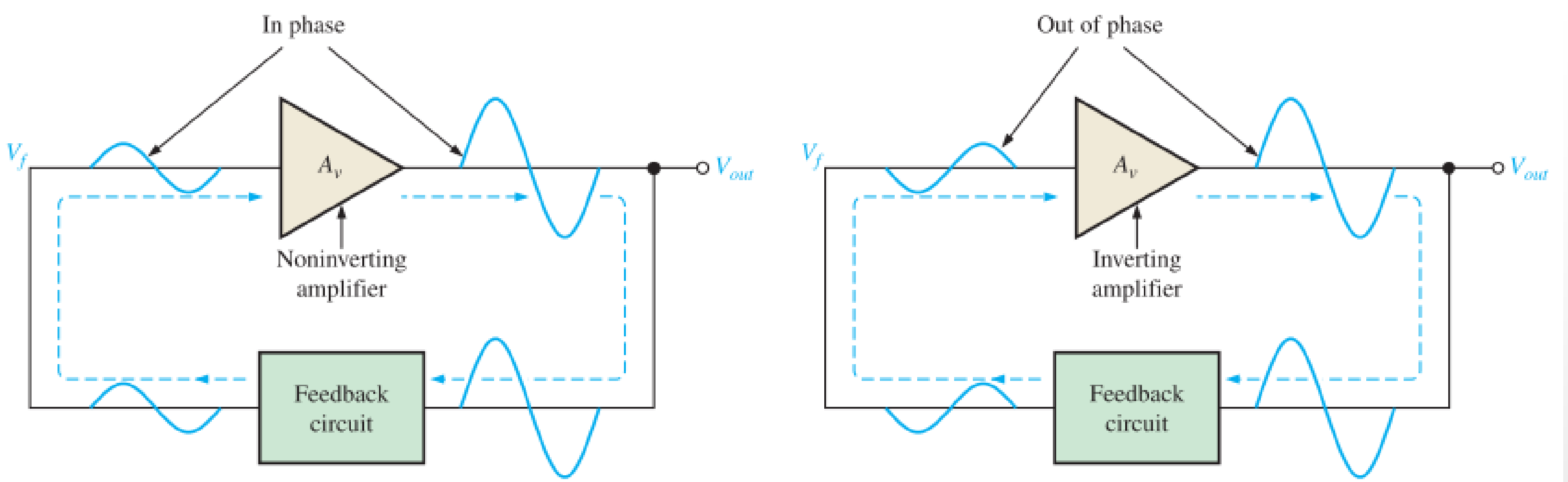
Positive feedback

- Positive feedback is characterized by the condition wherein a portion of the output voltage of an amplifier is fed back to the input with no net phase shift, resulting in a reinforcement of the output signal.



Oscillator

Basic elements of a feedback oscillator.

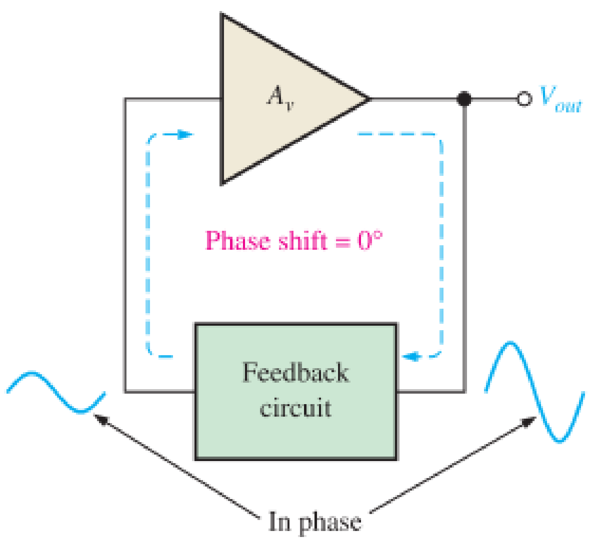


Conditions for Oscillation

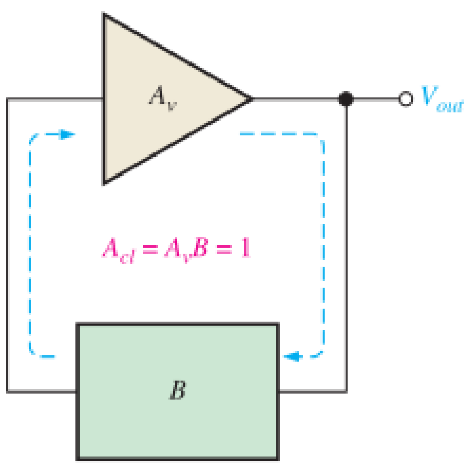
- Two conditions:

1. The phase shift around the feedback loop must be effectively 0°.
2. The voltage gain, A_{cl} around the closed feedback loop (loop gain) must equal 1 (unity).

$$A_{cl} = A_v B$$



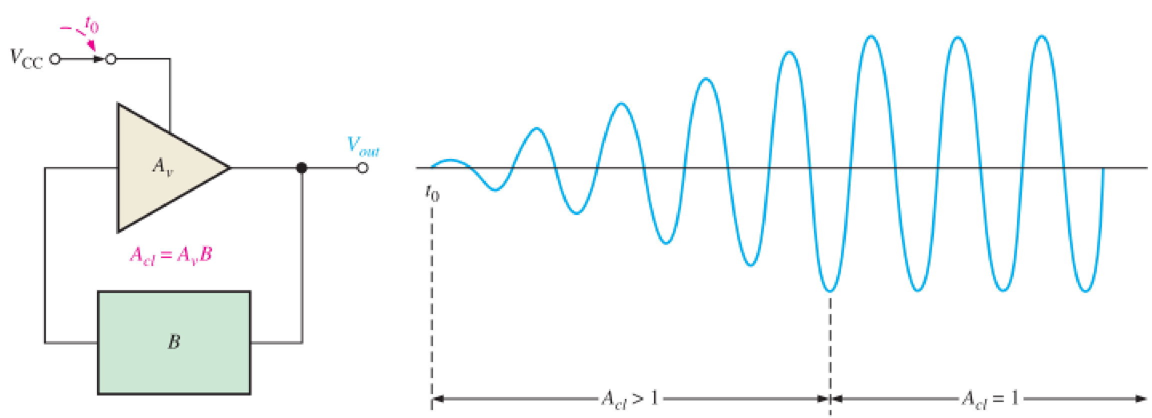
(a) The phase shift around the loop is 0°.



(b) The closed loop gain is 1.

Start-Up Conditions

- For oscillation to begin, the voltage gain around the positive feedback loop must be greater than 1 so that the amplitude of the output can build up to a desired level.
- The gain must then decrease to 1 so that the output stays at the desired level and oscillation is sustained.
- Initially, a small positive feedback voltage develops from thermally produced broad-band noise in the resistors or other components or from power supply turn-on transients.



Wien-bridge oscillator

Phase-shift oscillator

Twin-T oscillator

OSCILLATORS WITH RC FEEDBACK CIRCUITS

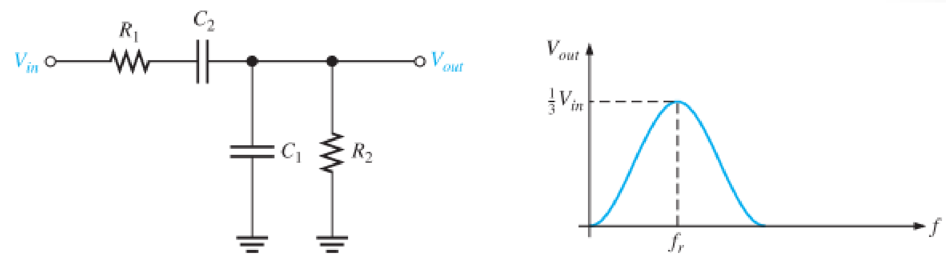
The Wien-Bridge Oscillator

- Generally, RC feedback oscillators are used for frequencies up to about 1 MHz.
- The Wien-bridge is by far the most widely used type of RC feedback oscillator for this range of frequencies.

$R_1 = R_2$ and $X_{C1} = X_{C2}$

$$\frac{V_{out}}{V_{in}} = \frac{1}{3}$$

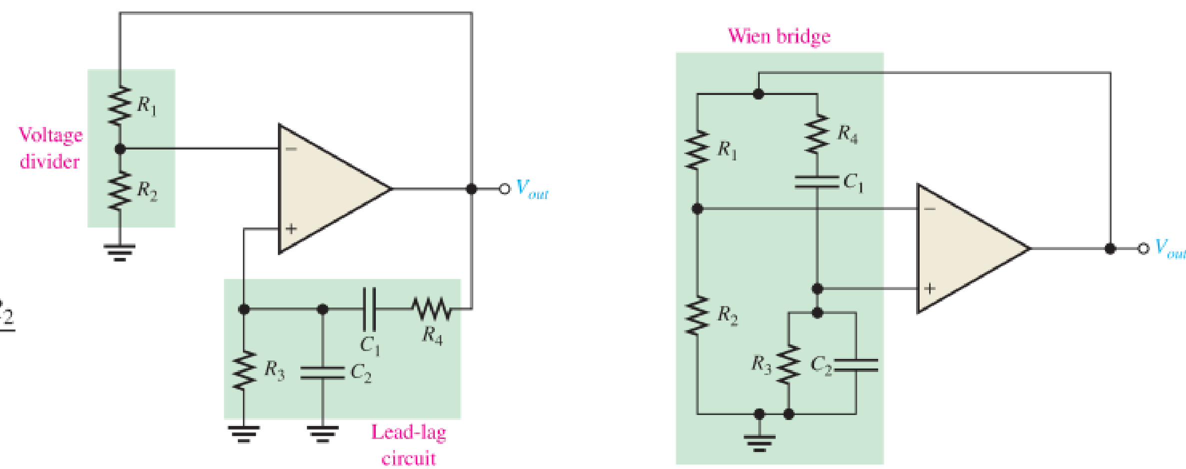
$$f_r = \frac{1}{2\pi RC}$$



Lead-lag circuit and its response curve

- **Basic Circuit**

$$A_{cl} = \frac{1}{B} = \frac{1}{R_2/(R_1 + R_2)} = \frac{R_1 + R_2}{R_2}$$



(a)

(b) Wien bridge circuit combines a voltage divider and a lead-lag circuit.

▲ FIGURE 16–7

The Wien-bridge oscillator schematic drawn in two different but equivalent ways.

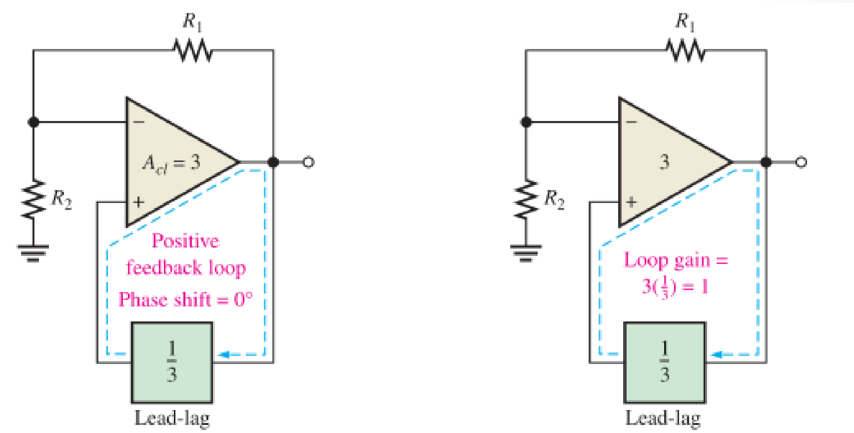
The Wien-Bridge Oscillator..

- Positive Feedback Conditions for Oscillation

$A_{cl} = 3$ → $A_{cl} = 1 + (R_1/R_2)$

choose $R_1 = 2R_2$

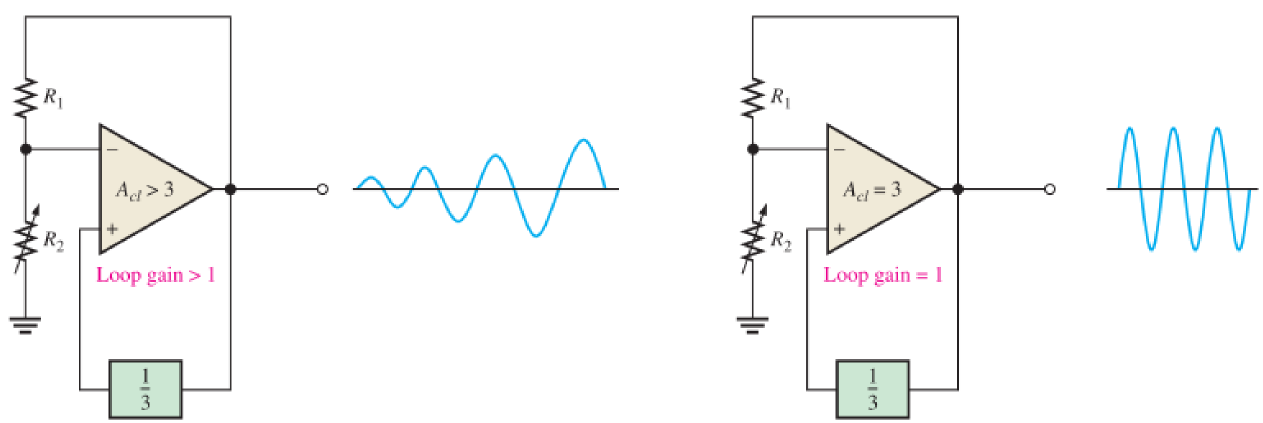
$$A_{cl} = \frac{R_1 + R_2}{R_2} = \frac{2R_2 + R_2}{R_2} = \frac{3R_2}{R_2} = 3$$



(a) The phase shift around the loop is 0°. (b) The voltage gain around the loop is 1.

- Start-Up Conditions

$(A_{cl} > 3)$



(a) Loop gain greater than 1 causes output to build up. (b) Loop gain of 1 causes a sustained constant output.

Self-starting Wien-bridge oscillator

Using a form of automatic gain control (AGC)

1- When dc power is first applied, both zener diodes appear as opens.

$$A_{cl} = \frac{R_1 + R_2 + R_3}{R_2} = \frac{3R_2 + R_3}{R_2} = 3 + \frac{R_3}{R_2}$$

2- When the zeners conduct, they short out R_3 and $A_{cl} = 3$

- The zener feedback is simple, it suffers from the nonlinearity of the zener diodes that occurs in order to control gain.

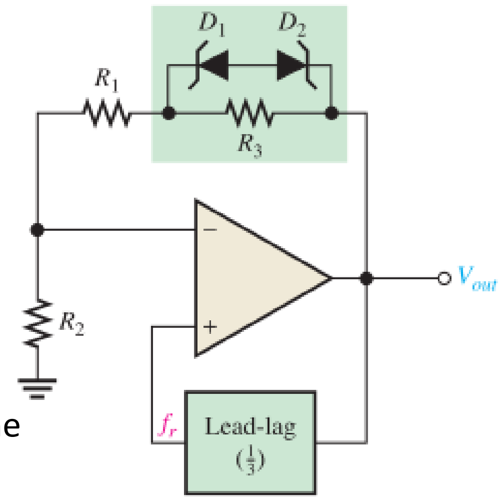


FIGURE 16–10

Self-starting Wien-bridge oscillator using back-to-back zener diodes.

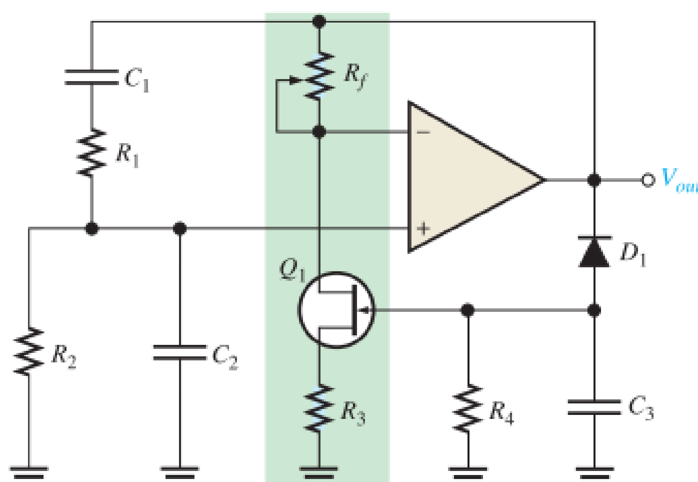
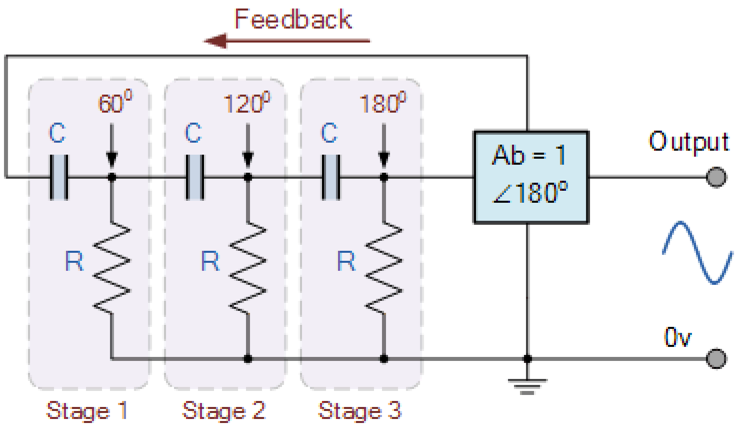


FIGURE 16–11

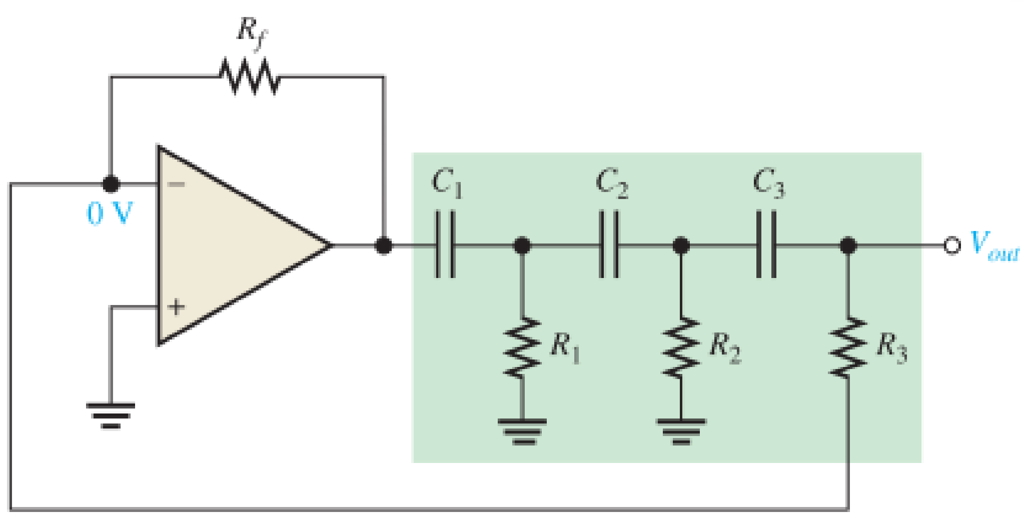
Self-starting Wien-bridge oscillator using a JFET in the negative feedback loop.

- In some older designs, a tungsten lamp was used in the feed-back circuit to achieve stability.
- A better method to control the gain uses a JFET as a voltage-controlled resistor in a negative feedback path.
- As the voltage increases, the drain-source resistance increases.

The Phase-Shift Oscillator



- Each of the three RC circuits in the feedback loop can provide a maximum phase shift approaching 90°.
- Oscillation occurs at the frequency where the total phase shift through the three RC circuits is 180°.
- The inversion of the op-amp itself provides the additional 180° to meet the requirement for oscillation of a 360° (or 0°) phase shift around the feedback loop.



$$B = \frac{1}{29} \qquad \text{where } B = R_3/R_f.$$

$$R_1 = R_2 = R_3 = R \text{ and } C_1 = C_2 = C_3 = C.$$

$$f_r = \frac{1}{2\pi\sqrt{6}RC}$$

Twin-T Oscillator

- One of the twin-T filters has a low-pass response, and the other has a high-pass response.
- The combined parallel filters produce a band-stop or notch response with a center frequency equal to the desired frequency of oscillation.

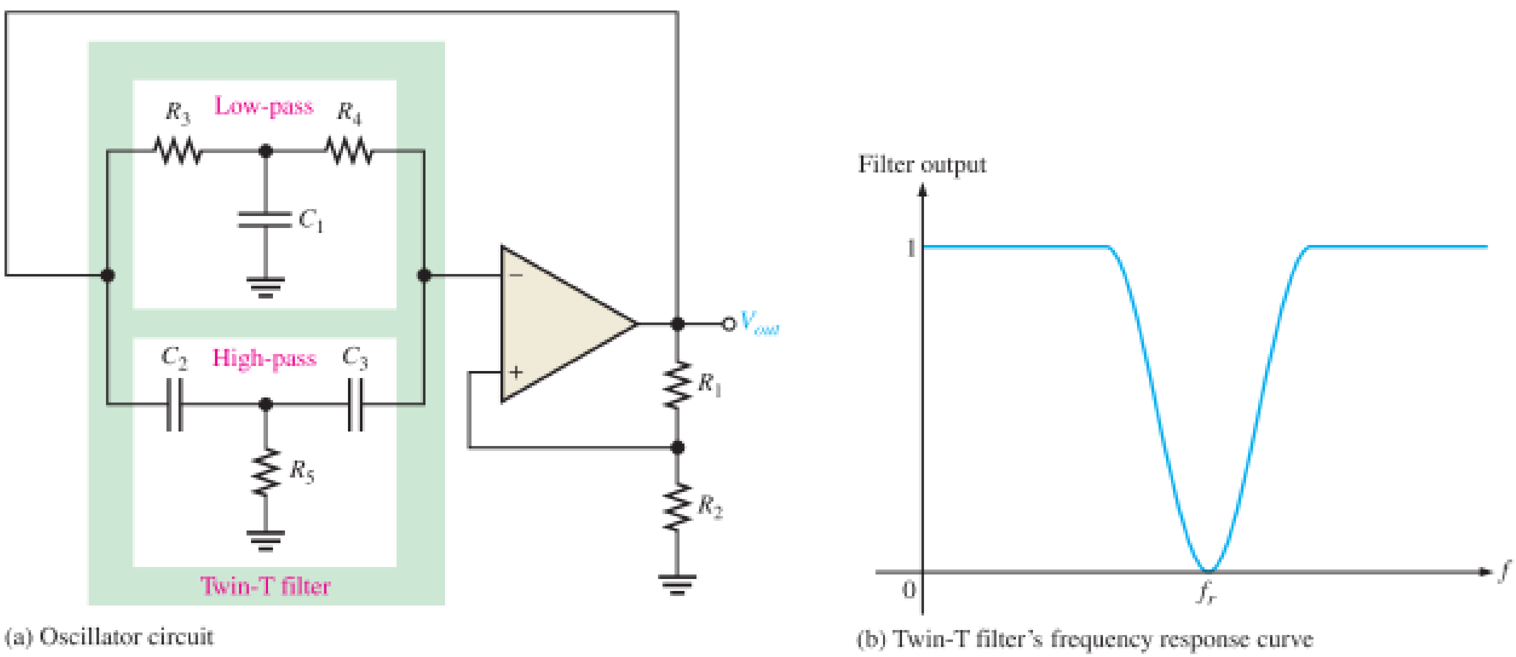


FIGURE 16–15

Twin-T oscillator and twin-T filter response.

- For more details, refer to:
  - Chapter 16 at T. Floyd, **Electronic Devices**,9th edition.
  - http://www.electronics-tutorials.ws/oscillator/rc_oscillator.html
  - http://www.electronics-tutorials.ws/oscillator/oscillators.html
- The lecture is available online at:
  - http://bu.edu.eg/staff/ahmad.elbanna-courses/11966
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