Lecture-1

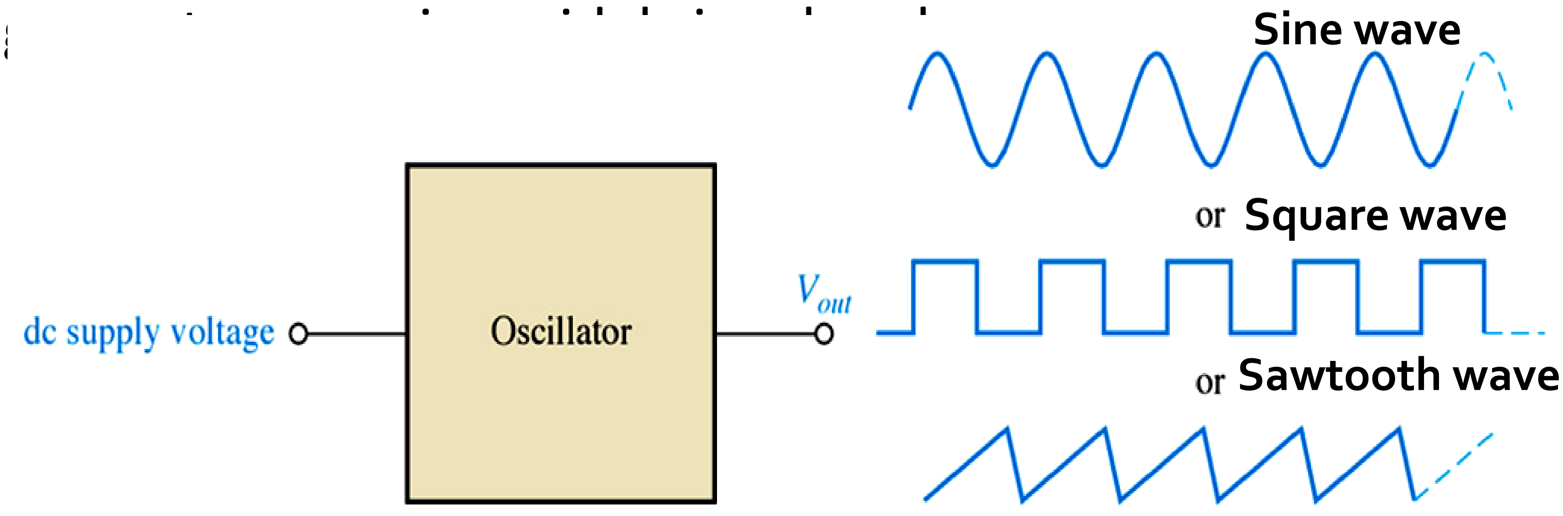
Oscillator Principal, Wein Bridge Oscillator

Introduction

- Oscillator is an electronic circuit that generates a periodic waveform on its output without an external signal source. It is used to convert dc to ac.
- Oscillators are circuits that produce a continuous signal of some type without the need of an input.
- These signals serve a variety of purposes.
- Communications systems, digital systems (including computers), and test equipment make use of oscillators

Introduction

- An oscillator is a circuit that produces a repetitive signal from a dc voltage.
- The feedback oscillator relies on a positive feedback of the output to maintain the oscillations.
- The relaxation oscillator makes use of an RC timing circuit to

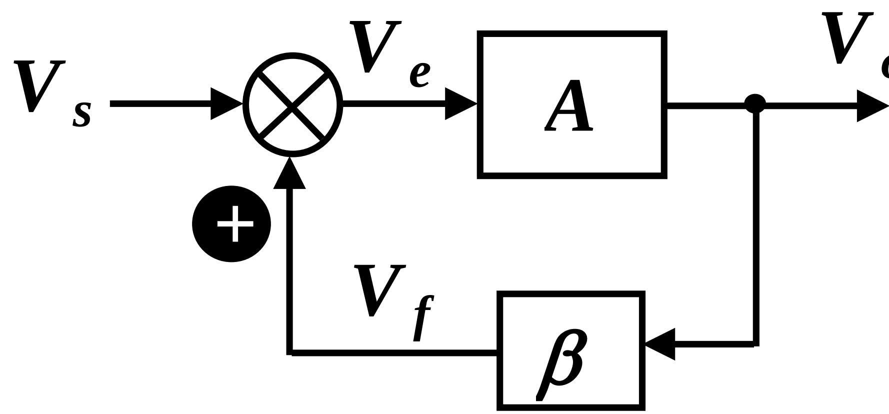


Types of oscillators

1. RC oscillators
   - Wien Bridge
   - Phase-Shift
2. LC oscillators
   - Hartley
   - Colpitts
   - Crystal
3. Unijunction / relaxation oscillators

Basic principles for oscillation

- An oscillator is an amplifier with positive feedback.



$$V_e = V_s + V_f \quad (1)$$

$$V_f = \beta V_o \quad (2)$$

$$V_o = AV_e = A(V_s + V_f) = A(V_s + \beta V_o) \quad (3)$$

Basic principles for oscillation

$$V_o = AV_e$$
$$= A\left(V_s + V_f\right) = A\left(V_s + \beta V_o\right)$$
$$V_o = AV_s + A\beta V_o$$
$$\left(1 - A\beta\right)V_o = AV_s$$

- The closed loop gain is: $A_f \equiv \dfrac{V_o}{V_s} = \dfrac{A}{\left(1 - A\beta\right)}$

Basic principles for oscillation

- In general A and β are functions of frequency and thus may be written as;

$$A_f(s) = \frac{V_o}{V_s}(s) = \frac{A(s)}{1 - A(s)\beta(s)}$$

$A(s)\beta(s)$ is known as loop gain

Basic principles for oscillation

$$T(s) = A(s)\beta(s)$$

- Writing $T(s) = A(s)\beta(s)$ the loop gain becomes:

$$A_f(s) = \frac{A(s)}{1 - T(s)}$$

- Replacing s with $j\omega$

$$A_f(j\omega) = \frac{A(j\omega)}{1 - T(j\omega)}$$

- and

$$T(j\omega) = A(j\omega)\beta(j\omega)$$

Basic principles for oscillation

- At a specific frequency f_0

$$T(j\omega_0) = A(j\omega_0)\beta(j\omega_0) = 1$$

- At this frequency, the closed loop gain;

$$A_f(j\omega_0) = \frac{A(j\omega_0)}{1 - A(j\omega_0)\beta(j\omega_0)}$$

will be infinite, i.e. the circuit will have finite output for zero input signal - oscillation

Basic principles for oscillation

- Thus, the condition for sinusoidal oscillation of frequency f_0 is;

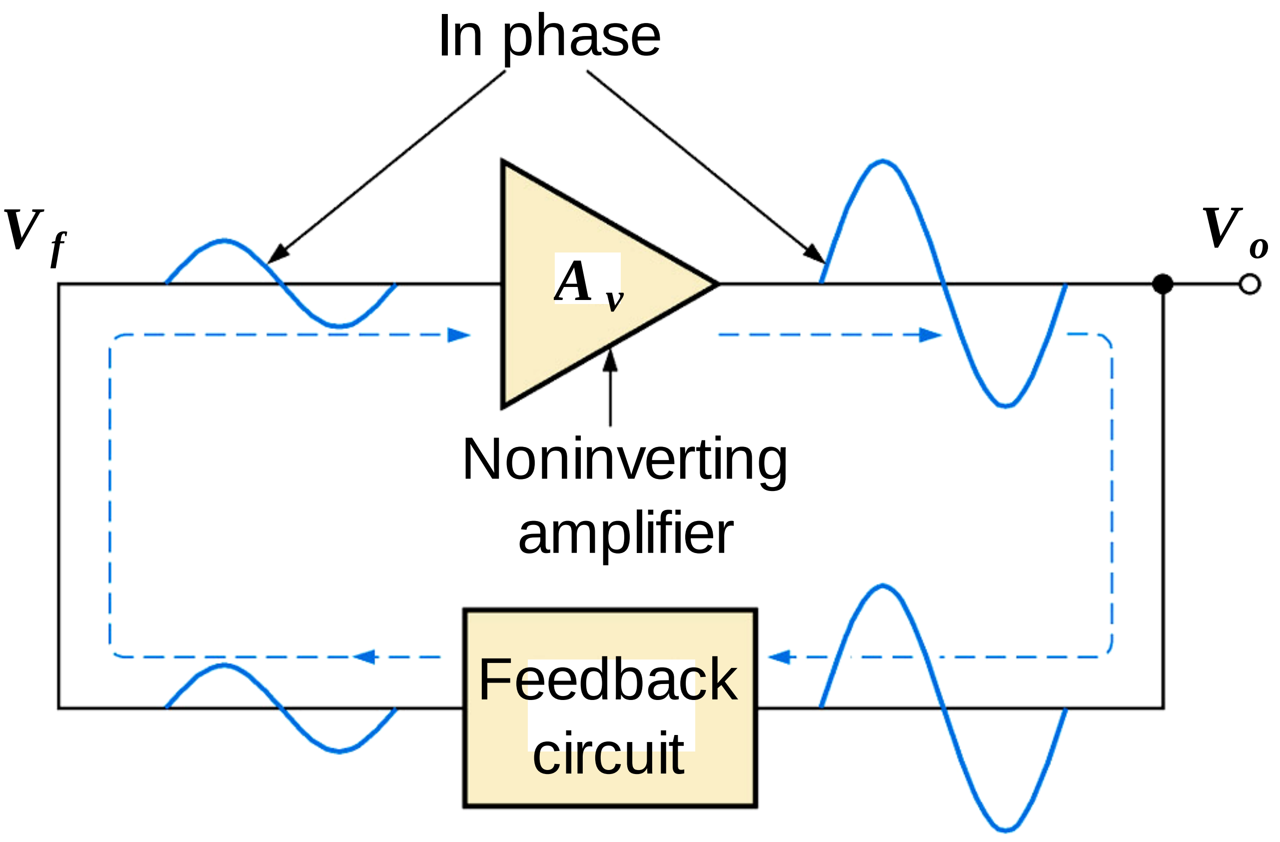
$$A(j\omega_0)\beta(j\omega_0) = 1$$

- This is known as Barkhausen criterion.
- The frequency of oscillation is solely determined by the phase characteristic of the feedback loop – the loop oscillates at the frequency for which the phase is zero.

Basic principles for oscillation

- The feedback oscillator is widely used for generation of sine wave signals.
- The positive (in phase) feedback arrangement maintains the oscillations.
- The feedback gain must be kept to unity to keep the output from distorting.

Basic principles for oscillation



Design Criteria for Oscillators

1. The magnitude of the loop gain must be unity or slightly larger

   $$|A\beta| = 1$$ – Barkhaussen criterion

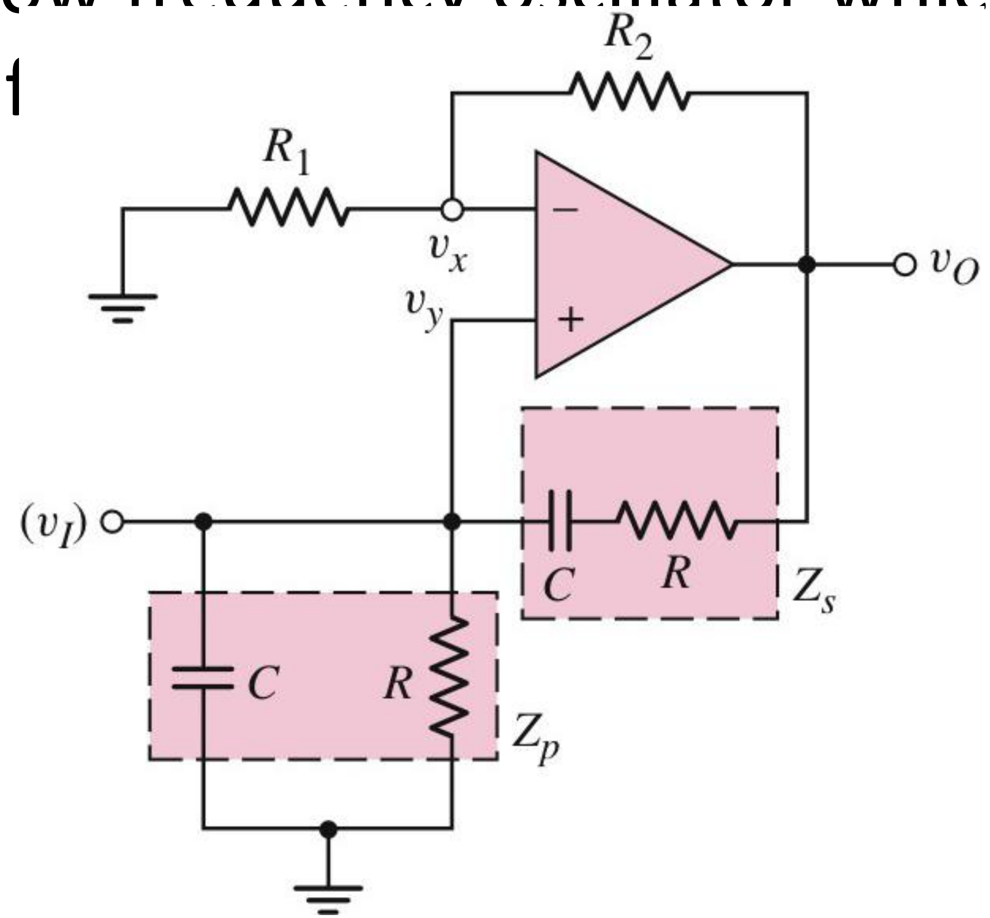
2. Total phase shift, ϕ of the loop gain mus t be Nx360° where N=0, 1, 2, …

RC Oscillators

- RC feedback oscillators are generally limited to frequencies of 1 MHz or less.
- The types of RC oscillators that we will discuss are the Wien-bridge and the phase-shift

Wien-bridge Oscillator

- It is a low frequency oscillator which ranges from a f



Wien-bridge Oscillator

- The loop gain for the oscillator is;

$$T(s) = A(s)\beta(s) = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{Z_p}{Z_p + Z_s}\right)$$

- where; $Z_p = \dfrac{R}{1 + sRC}$

- and; $Z_s = \dfrac{1 + sRC}{sC}$

Wien-bridge Oscillator

- Hence; $$T(s)=\left(1+\frac{R_2}{R_1}\right)\left[\frac{1}{3+sRC+(1/sRC)}\right]$$
- Substituting for s; $$T(j\omega)=\left(1+\frac{R_2}{R_1}\right)\left[\frac{1}{3+j\omega RC+(1/j\omega RC)}\right]$$
- For oscillation frequency f_0; $$T(j\omega_0)=\left(1+\frac{R_2}{R_1}\right)\left[\frac{1}{3+j\omega_0 RC+(1/j\omega_0 RC)}\right]$$

Wien-bridge Oscillator

- Since at the frequency of oscillation, $T(j\omega)$ must be real (for zero phase condition), the imaginary component must be zero;

$$j\omega_0 RC + \frac{1}{j\omega_0 RC} = 0$$

- Which gives us, $\omega_0 = \frac{1}{RC}$

Wien-bridge Oscillator

- From the previous equation;

$$T(j\omega_0) = \left(1+\frac{R_2}{R_1}\right)\left[\frac{1}{3+j\omega_0 RC+(1/j\omega_0 RC)}\right]$$

- the magnitude condition is;

$$1 = \left(1+\frac{R_2}{R_1}\right)\left(\frac{1}{3}\right) \qquad \frac{R_2}{R_1} = 2$$

To ensure oscillation, the ratio R_2/R_1 must be slightly greater than 2.

Wien-bridge Oscillator

- With the ratio; $\frac{R_2}{R_1} = 2$

- then; $K \equiv 1 + \frac{R_2}{R_1} = 3$

$K = 3$ ensures the loop gain of unity – oscillation

- $K > 3$: growing oscillations
- $K < 3$: decreasing oscillations