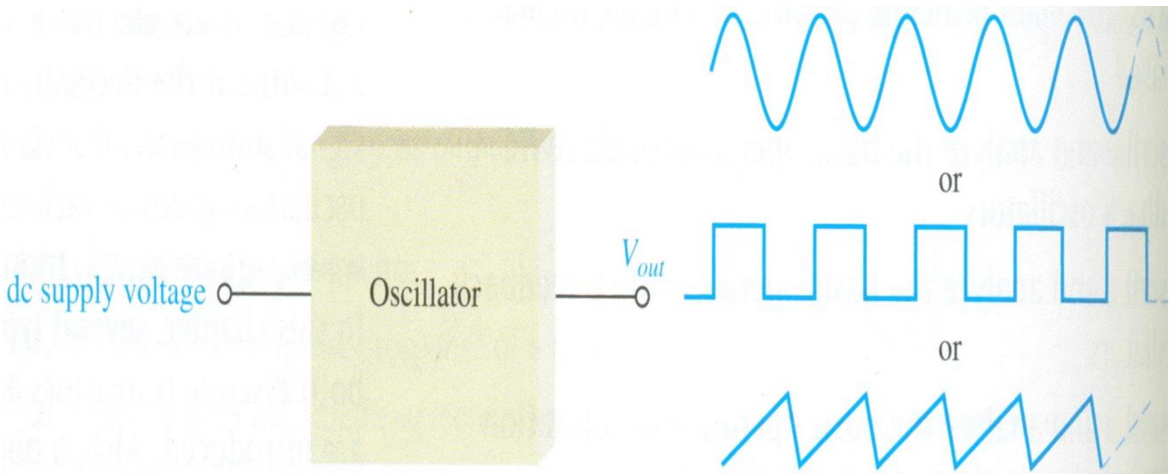
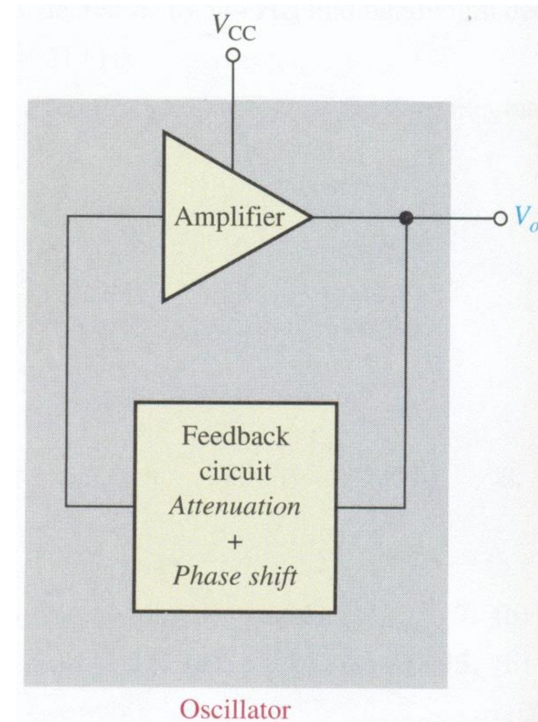
Lecture 29: Oscillators

Conditions for Oscillations, Colpitts Oscillator, Hartley Oscillator, Armstrong Oscillator, Examples

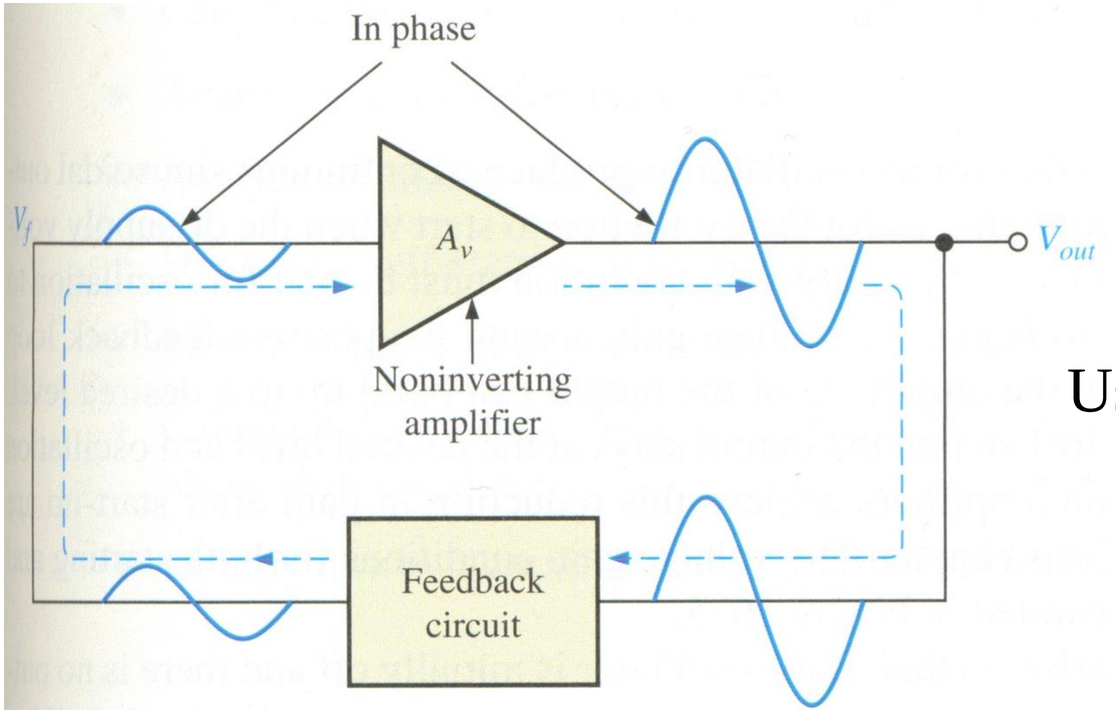
Feedback Oscillators





A feedback oscillator is created by forming a closed loop consisting of an amplifier with voltage gain (A_v) and a feedback circuit with attenuation (B).

Conditions for Oscillations

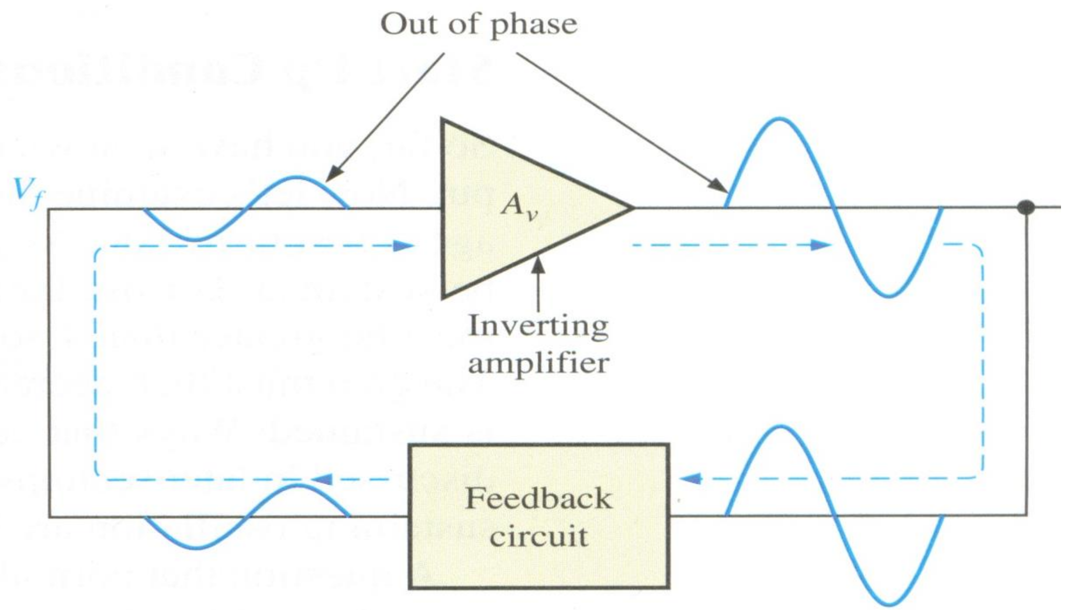


Using Non-Inverting Amplifiers

$$A_{cl} \equiv \text{voltage gain around the closed loop} = A_v\ B = 1$$

feedback circuit introduces no phase shift

Conditions for Oscillations (Cont'd)

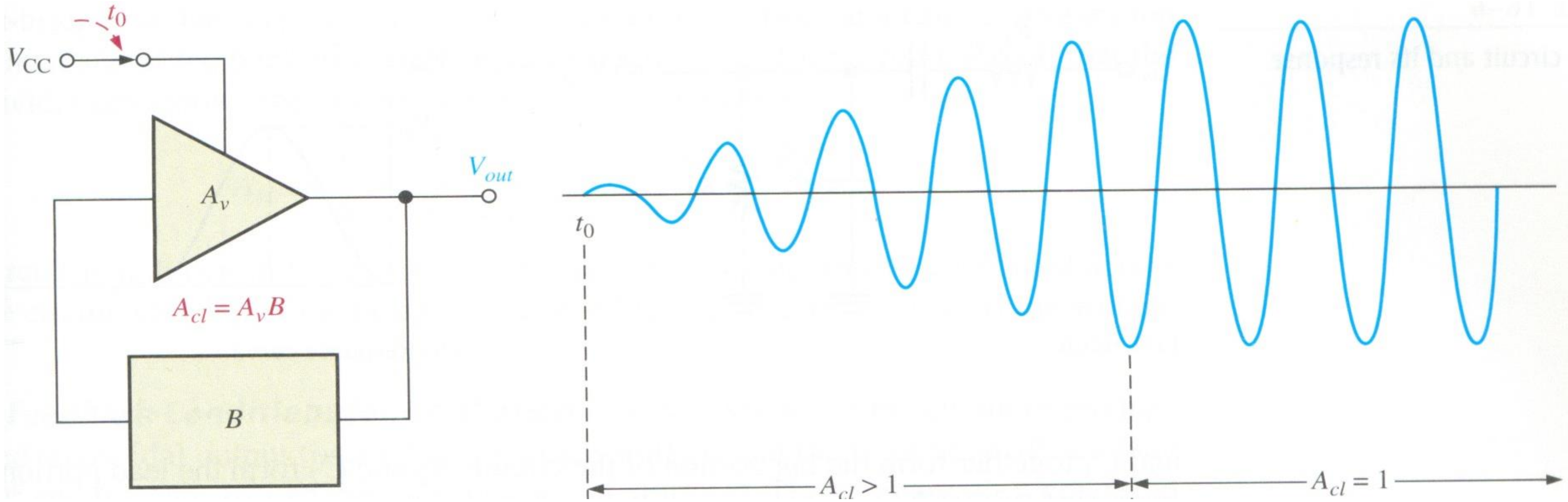


Using Inverting Amplifiers

$$A_{cl} \equiv \text{voltage gain around the closed loop} = A_v\ B = 1$$

feedback circuit introduces 180^o phase shift

Starting Oscillations



the power supply turn-on transients generate all frequency components in the oscillator loop

initially, the amplitude of the frequency component is weak requiring $A_{cl} > 1$ at start-up

after the desired level is reached, A_{cl} should drop back to 1, for maintaining stable oscillations

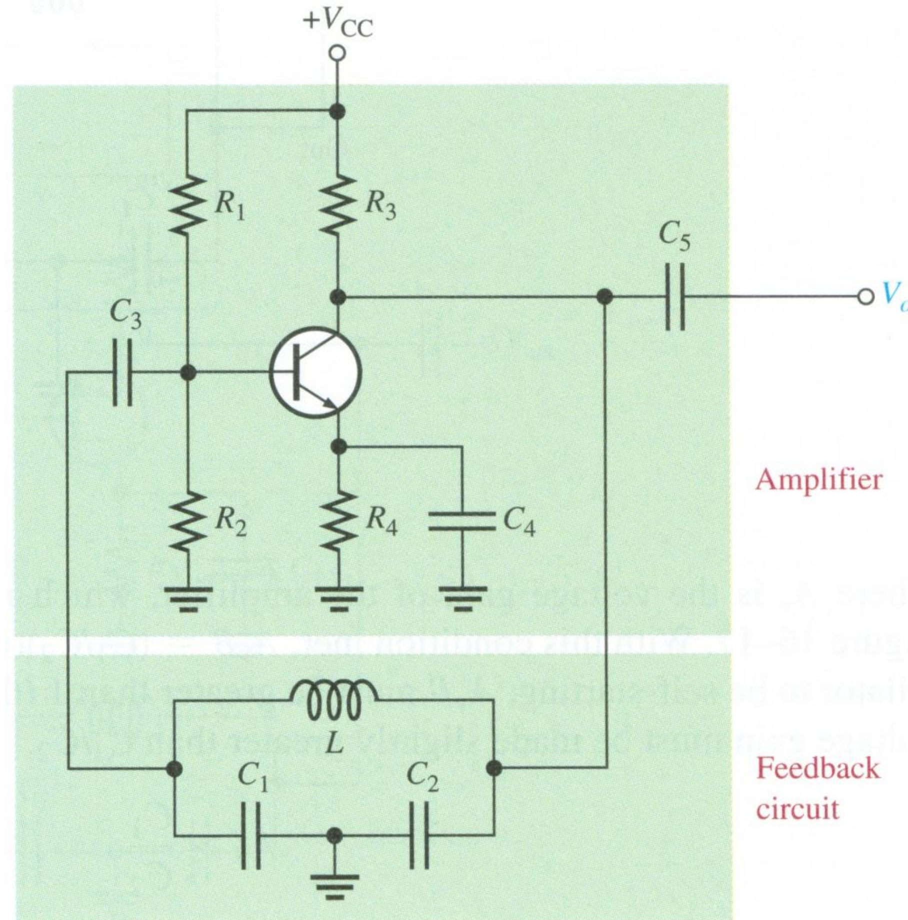
Colpitts Oscillator

the amplifier used is a common-emitter (CE) BJT amplifier

the feedback circuit is a frequency selective ideal parallel resonance circuit, whose resonance frequency is:

$$f_0 = \frac{1}{2\pi\sqrt{LC_T}},$$

$$C_T \equiv \text{total capacitance} = \frac{C_1 \; C_2}{C_1 + C_2}$$

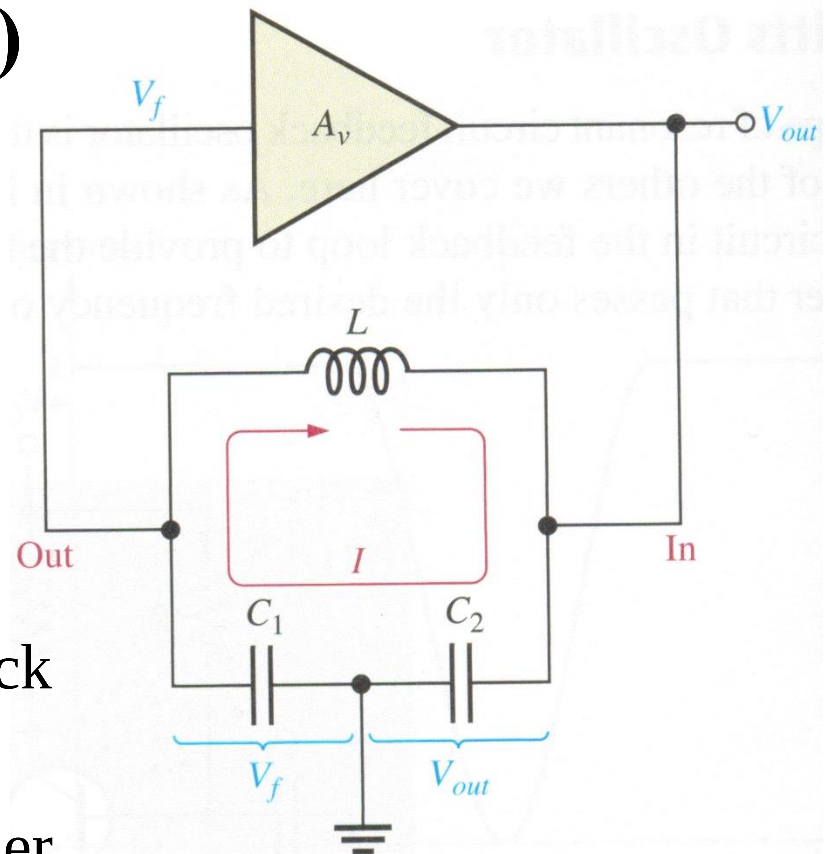


Colpitts Oscillator (Cont'd)

attenuation (B) of the feedback circuit

$$B \equiv \text{attenuation} = \frac{V_f}{V_{out}} \cong \frac{-I\ X_{C1}}{I\ X_{C2}} = -\frac{X_{C1}}{X_{C2}}$$

$$= -\frac{1/(2\pi f_r C_1)}{1/(2\pi f_r C_2)} = -\frac{C_2}{C_1}$$



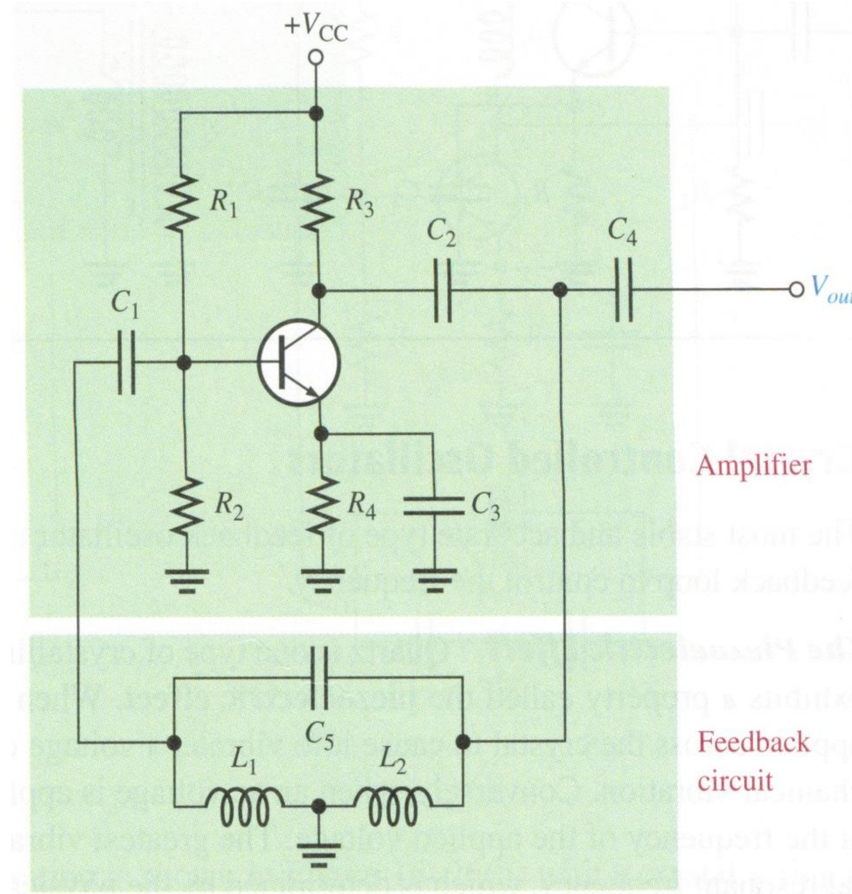
the -ve sign indicates that the feedback circuit introduces 180° phase shift

knowing B, the gain of the amplifier can be obtained such that the condition of oscillation is satisfied:

$$A_{cl} = A_v\ B = 1 \quad \Rightarrow \quad A_v = \frac{1}{B} = -\frac{C_1}{C_2}$$

Hartley Oscillator

interchanging capacitors and inductors in a Colpitts oscillator results in a Hartley oscillator



$$f_0 = \frac{1}{2\pi\sqrt{L_T C}},$$

$$L_T \equiv \text{total inductance} = L_1 + L_2$$

the attenuation (B) of the feedback circuit and the gain (A_v) of the amplifier can be expressed as follows:

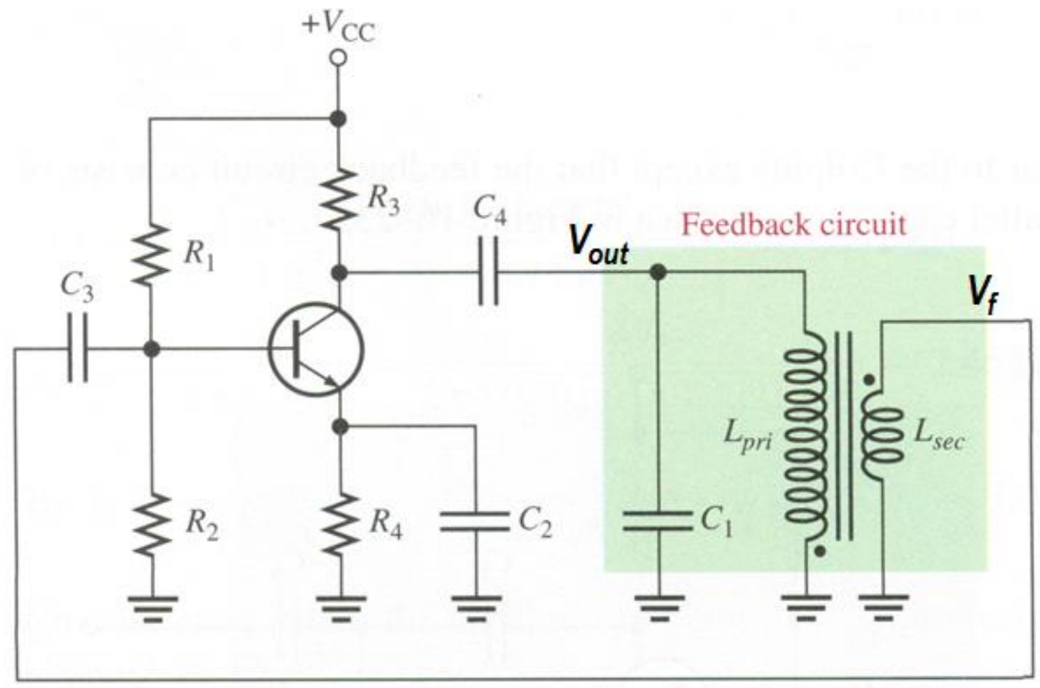
$$B = \frac{V_f}{V_{out}} \cong \frac{-I\ X_{L1}}{I\ X_{L2}} = -\frac{X_{L1}}{X_{L2}} = -\frac{2\pi f_r L_1}{2\pi f_r L_2} = -\frac{L_1}{L_2},\ \ A_v = \frac{1}{B} = -\frac{L_2}{L_1}$$

Armstrong Oscillator

a transformer is used as a feedback circuit

the frequency of oscillation is:

$$f_0 = \frac{1}{2\pi\sqrt{L_{pri}C_1}}$$



the attenuation (B) of the feedback circuit and the gain (A_v) of the amplifier are:

$$B = \frac{V_f}{V_{out}} = -\frac{N_{\sec}}{N_{pri}} = -n, \quad A_v = \frac{1}{B} = -\frac{1}{n}$$