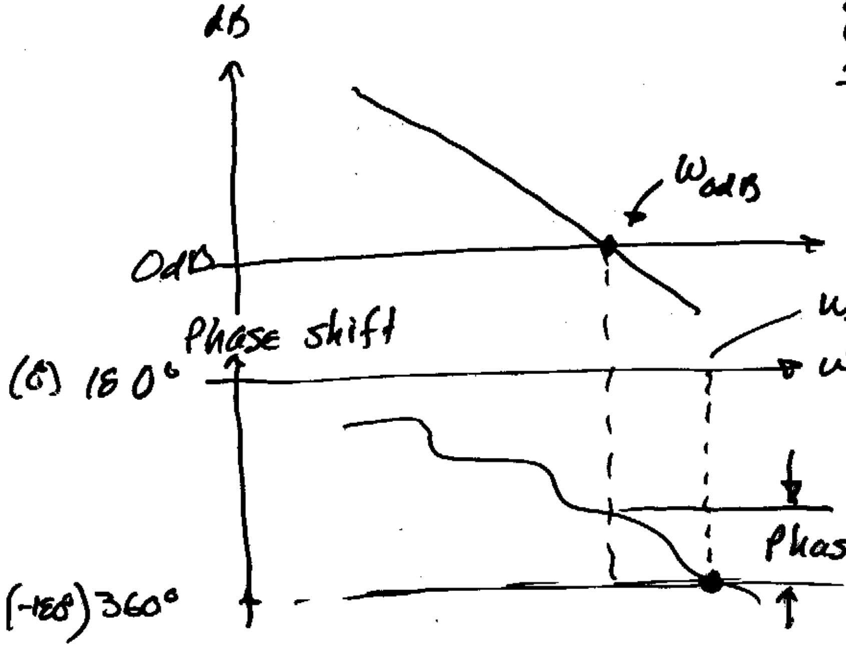
Bode Feedback Stability Conditions

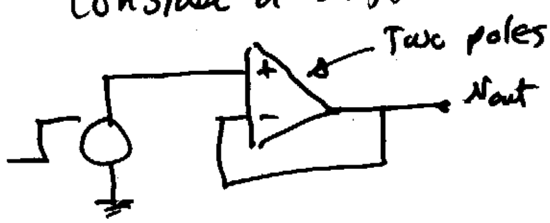
1.) $\text{Arg}\left[T(j\omega_{0dB})\right] > -180^\circ$ → The loop phase shift is greater than -180° when the loop magnitude $=1$

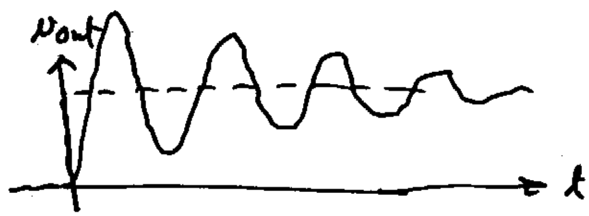
2.) $\left|T(j\omega_{-180^\circ})\right| < 1$ → The magnitude of the loop gain must be less than 1 when loop phase shift $= -180^\circ$.



A good system has a phase margin $\geq 45^\circ$.

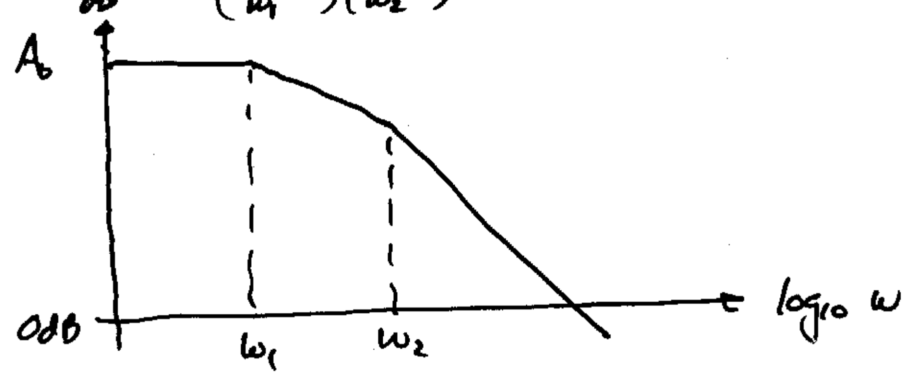
Consider a buffer -





Self Example

$$A(s) = \frac{A_0}{\left(\frac{s}{\omega_1}+1\right)\left(\frac{s}{\omega_2}+1\right)} \qquad B(s) = B_0$$



OSCILLATORS

Intro

- Oscillators all use some form of positive feedback along a frequency dependent transfer function to create periodic waveforms.
- Classification of oscillators

  Tuned – sinusoidal
  Untuned – sq. wave, triangle, etc.

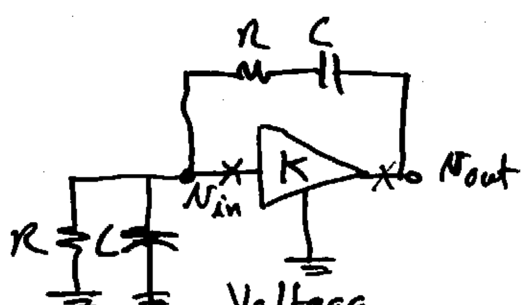
Criteria for oscillation

$$\text{Loop gain} = T(j\omega) = 1 + j0 = 1\angle 0^\circ$$

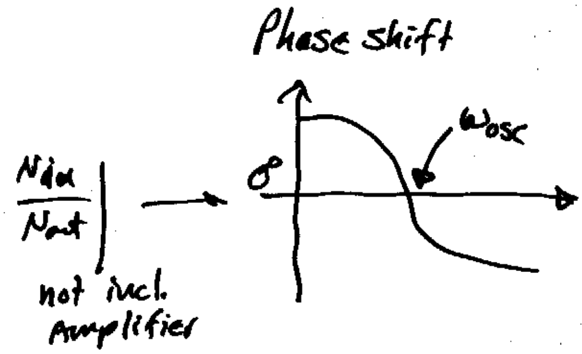
From this eq. you get:

1.) Freq. of oscillation
2.) Gain necessary for oscillation

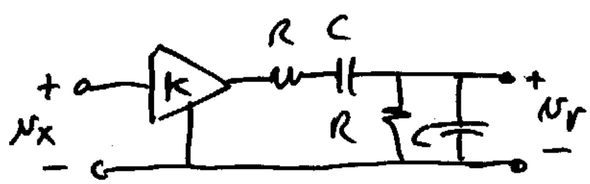
Wien Bridge Oscillator



Voltage Amplifier



Open-loop



$$T(s) = \frac{V_r(s)}{V_x(s)} = K\,\frac{R \parallel \frac{1}{sC}}{R + \frac{1}{sC} + R \parallel \frac{1}{sC}}$$

$$R \parallel \frac{1}{sC} = \frac{R/sC}{R + \frac{1}{sC}} = \frac{R}{sRC+1}$$

$$T(s) = \frac{K\,\frac{R}{sRC+1}}{\frac{sRC+1}{sC} + \frac{R}{sRC+1}} \times \frac{sC(sRC+1)}{sC(sRC+1)}$$

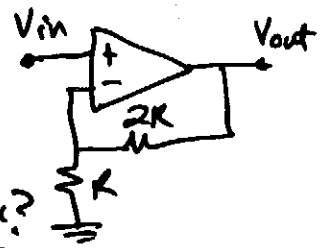
Cont'd

$$T(s) = \frac{K\, sRC}{(sRC+1)^2 + sRC} = \frac{sKRC}{s^2R^2C^2 + s3RC + 1}$$

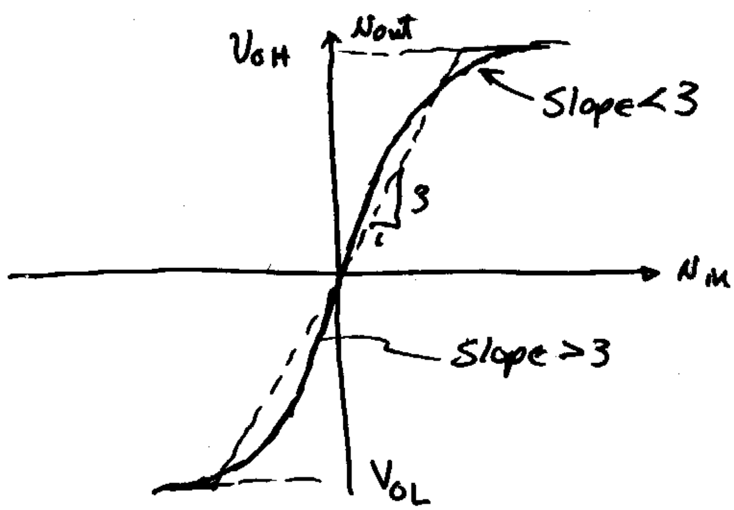
$$T(j\omega) = \frac{j\omega KRC}{\left[1-\omega^2R^2C^2\right] + j\omega 3RC} = 1 + j0$$

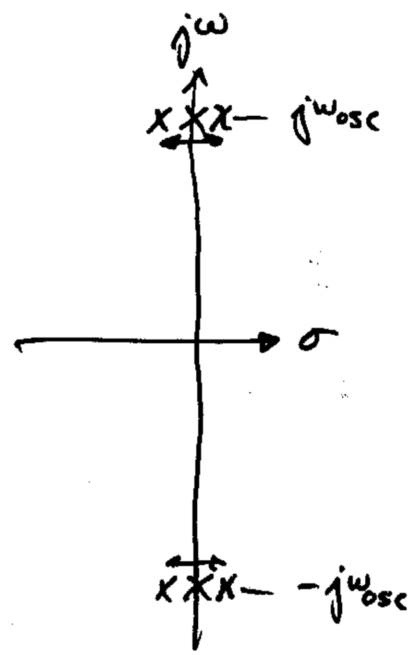
a.) $1-\omega^2R^2C^2 = 0 \rightarrow \boxed{\omega_{osc} = \frac{1}{RC}}$

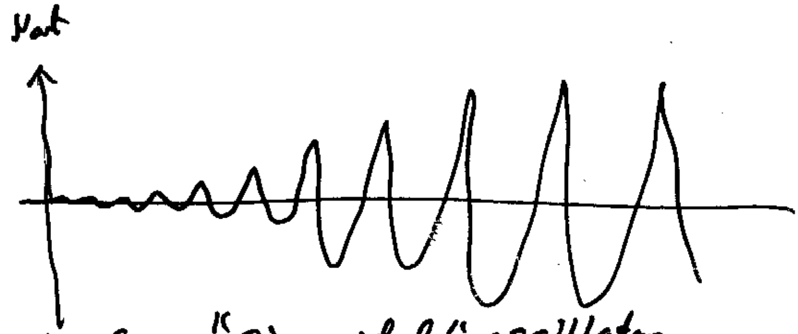
b.) $\frac{j\omega KRC}{j\omega 3RC} = 1 \rightarrow \boxed{K=3} \rightarrow$



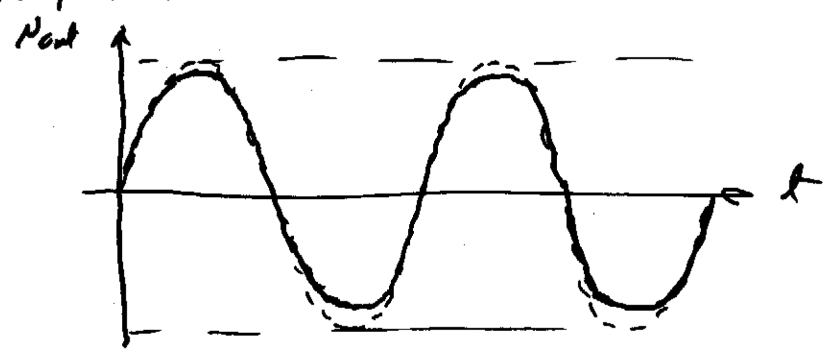
What determines the amplitude of oscillation?





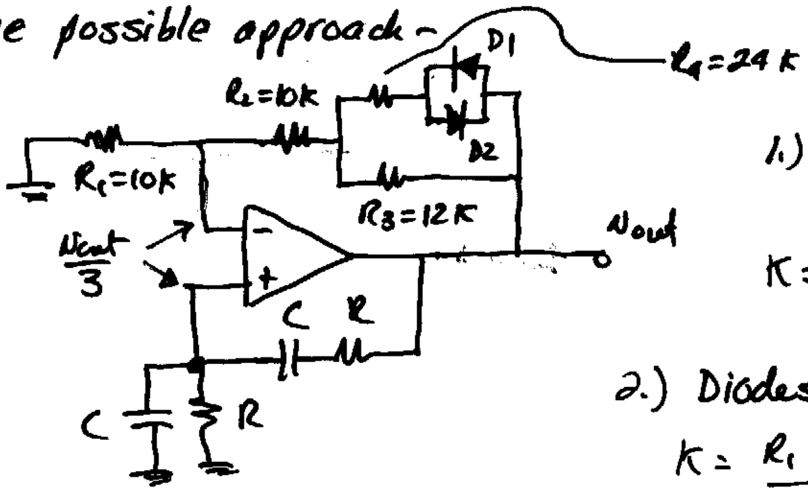


Output of a "sinusoidal" oscillator.



How do you accomplish the amplitude stabilization?

One possible approach –



1.) Diodes OFF

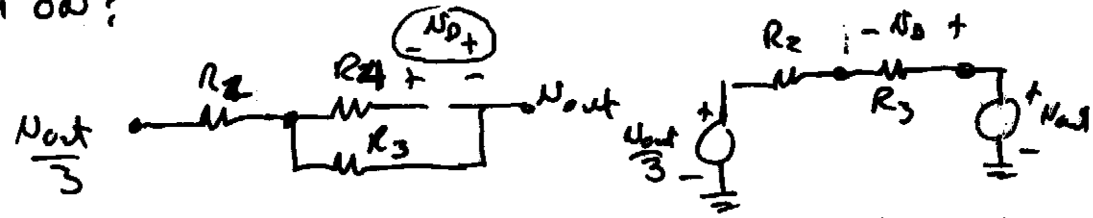
$R_4 = \infty$

$$K = \frac{R_1 + R_2 + R_3}{R_1} = \frac{32K}{10K} = 3.2$$

2.) Diodes ON

$$K = \frac{R_1 + R_2 + R_3 \| R_4}{R_1} = \frac{28K}{10K} = 2.8$$

What amplitude does the diodes turn ON?



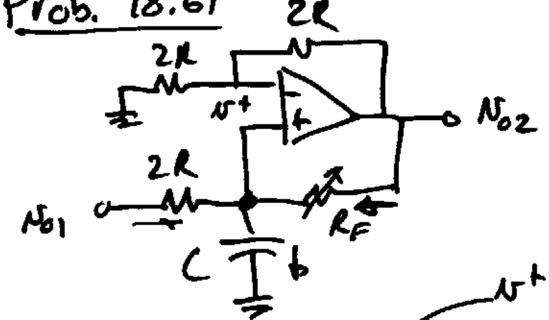
$$v_D = v_{out}\frac{R_3}{R_2+R_3} - \frac{v_{out}}{3}\frac{R_3}{R_2+R_3} = \frac{R_3}{R_2+R_3}\left(\frac{2}{3}v_{out}\right)$$

Assume $v_D = 0.6V$, then

$$0.6V \times \frac{R_2+R_3}{R_3} = v_{out}\frac{2}{3}$$

$$0.6 \times \frac{22K}{12K} \times \frac{3}{2} = v_{out} \simeq 0.6\ \cancel{2} \times \frac{3}{\cancel{2}} \simeq 1.8V$$

Prob. 18.61



Σi at v^+ gives

$$\frac{v_{01} - v^+}{2R} + \frac{v_{02} - v^+}{R_F} = sCv_+$$

$$v^+\left[sC + \frac{1}{2R} + \frac{1}{R_F}\right] = \frac{v_{01}}{2R} + \frac{v_{02}}{R_F}$$

$v_{02} = 2v^+$

$$\frac{v_{02}}{v_{01}}$$