Remainder of course ...

4th ED.	5th ED.	
	12	Filters and tuned amplifiers

Week 9 / Week 10 Lab:
- Filter types + specifcation → LC circuits
- Filter transfer function
- Op-amp filter circuits
- Mathematical basis
- Butterworth + chebychev filters, higher order filters.

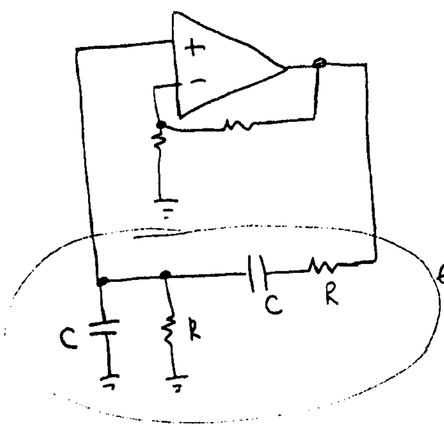
13 Signal Generators and waveform shaping

Today → / This week's lab:
- Sinusoidal oscillators
- LC and crystal oscillators

Week 10 / Last lab (week 11):
- Bistable multivibrators
- Astable multivibrators
- Timer circuits

Wein-Bridge Oscillator

Idea: positive feedback -
poles on the right side -
oscillates



Positive feedback network.
↓
is a <u>bandpass</u>.

Final
Fri - 10-12
Lab Final
Either:
Thurs 7:30-9:30
or
Tues 10-12

Analysis:
Voltage divider..

$$\frac{\frac{1}{\frac{1}{R}+Cs}}{\frac{1}{\frac{1}{R}+Cs}+\frac{1}{Cs}+R} = \frac{1}{1+\frac{\frac{1}{R}+Cs}{Cs}+\left(\frac{1}{R}+Cs\right)R}$$

$$= \frac{Cs}{Cs+\frac{1}{R}+Cs+\left(\frac{1}{R}+Cs\right)RCs} = \longrightarrow$$

$$= \frac{Cs}{Cs+\frac{1}{R}+Cs+\frac{RCs}{R}+RC^2s^2} = \frac{RCs}{RCs+1+RCs+RCs+R^2C^2s^2}$$

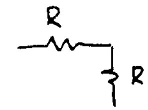
$$= \frac{RCs}{1+3RCs+R^2C^2s^2}$$

is a bandpass →

		<u>Gain</u>
$s=0$	⇒	0
$s=\infty$	⇒	$\frac{\infty}{\infty^2}=\frac{1}{\infty}=0$

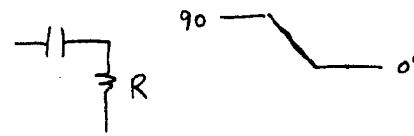
Phase -

Mid frequency -



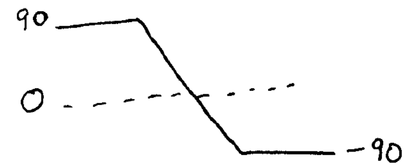
→ 0°

Low frequency



High frequency

Composite:



General form of a band pass --

$$\frac{K \frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2} \quad \text{or} \quad \frac{\frac{K}{Q\omega_0} s}{\frac{1}{\omega_0^2} s^2 + \frac{1}{Q\omega_0} s + 1}$$

Gain is maximized when $s = \omega_0$ (or $s = j\omega_0$)

$$Q = \frac{\omega_0}{\text{3db bandwidth}}$$

($Q = \infty$ makes middle term $= 0$)

Back to the Wein bridge...

$$RC = \frac{1}{\omega_0} \qquad \left(\text{for } \omega_0 = \frac{1}{RC}\right)$$

$$3RC = \frac{1}{Q\omega_0} = \frac{1}{\omega_0 \frac{BW}{\omega_0}} = \frac{1}{BW}$$

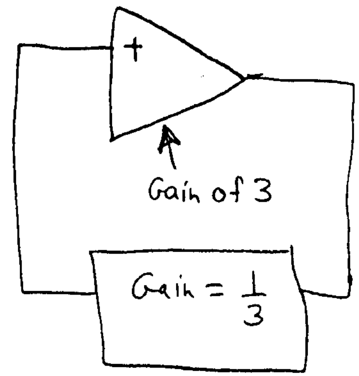
$$BW = \frac{1}{3RC}$$

↑ bandwidth

$$3RC = \frac{1}{Q\omega_0} = \frac{1}{Q}\,\frac{1}{\omega_0} \rightarrow \text{so } Q = \frac{1}{3}$$

($\frac{1}{Q}$ ↑ must be 3; $\frac{1}{\omega_0}$ ↑ RC)

(diversion was to show the analysis technique)



"Loop gain" = 1 exactly, for a good oscillator

Problem: Can't have "exactly".

Set it too high — distorted output

too low — doesn't oscillate.

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Solution

Tolerate a little distortion.

Make some deliberately -

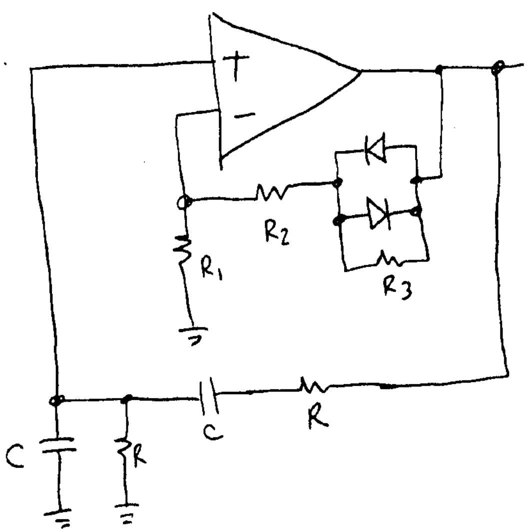
Make gain > 3 for low level

< 3 for high level

with a smooth transition -

Level will seek the place where it is exactly 3.

Use a pair of diodes



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Choose $R_2 + R_3$ and R_1 for a gain a little higher than 3 (3.5)

→ enough higher so it is always higher even with component tolerances.

If gain too high — stretched zone in the middle

too low - doesn't oscillate.

When diodes turn on --

R_3 and a diode are in parallel -

Diode has some equivalent resistance (slope of curve)

Choose R_2 so $R_2 + (R_3 \| \text{diode})$ gives a gain less than 3,