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Exercise 4:
(More) Filters

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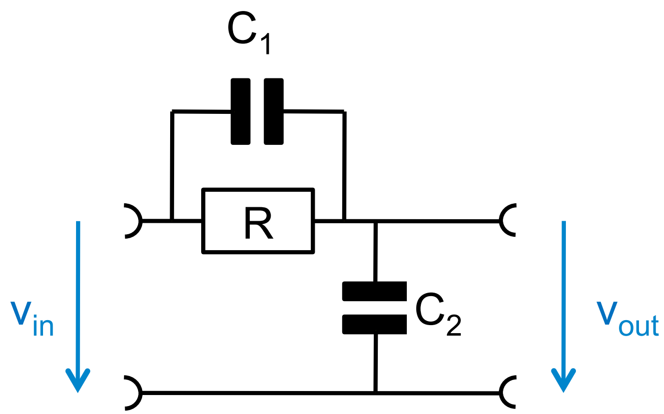
Exercise 4.1

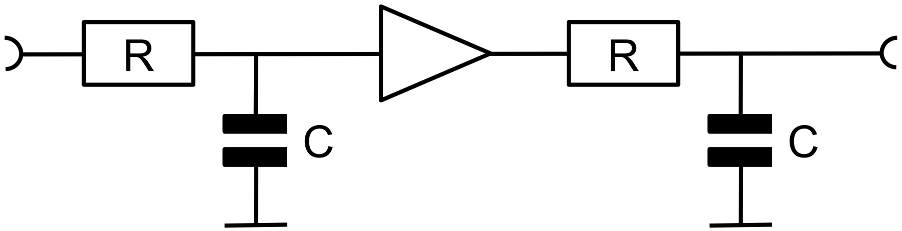
- Analyze the following circuit (simulation & calculation!):



- What is the transfer function ?
- At which frequencies are the 'pole' in the denominator and the 'zero' in the nominator ?
- What are gain and phase for $s \rightarrow 0$ and for $s \rightarrow \infty$? Why?
- What happens for $C_1 \rightarrow 0$, for $R \rightarrow 0$, for $R \rightarrow \infty$? Reasonable?
- Simulate the circuit for $C_1 = C_2 = 10$pF and R = 10 kΩ. Plot gain and phase!
- Chose values so that the circuit attenuates to 1/10 at high frequencies.
- For fun: At which frequency is phase shift maximal?

Exercise 4.2: Cascaded Stages

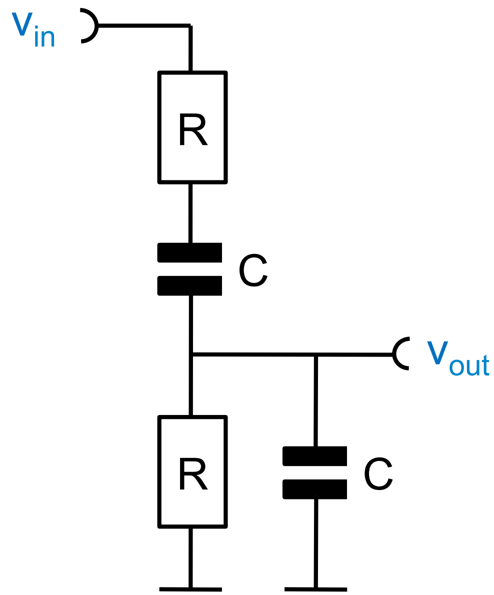
- Consider the following two stage circuit (again):



- The triangle is a (voltage) buffer with infinite input impedance (it does not load the first low-pass) and zero output impedance. From the analogLib, use vcvs (voltage controlled voltage source)
- What transfer function do you expect ?
- Simulate the circuit !
- **Simulate** *in parallel* a version **without** buffer.
  Where are differences ?
- Use a much larger R and correspondingly smaller C in the second low pass.
- Now **calculate** the exact transfer function **without** buffer

Exercise 4.3: Wien Bridge / Oscillator

- Consider this circuit:



- What is the transfer function?
- What is the magnitude at the center frequency?
- What is the Phase at the center frequency?
- Simulate the circuit for R=1k C=1n

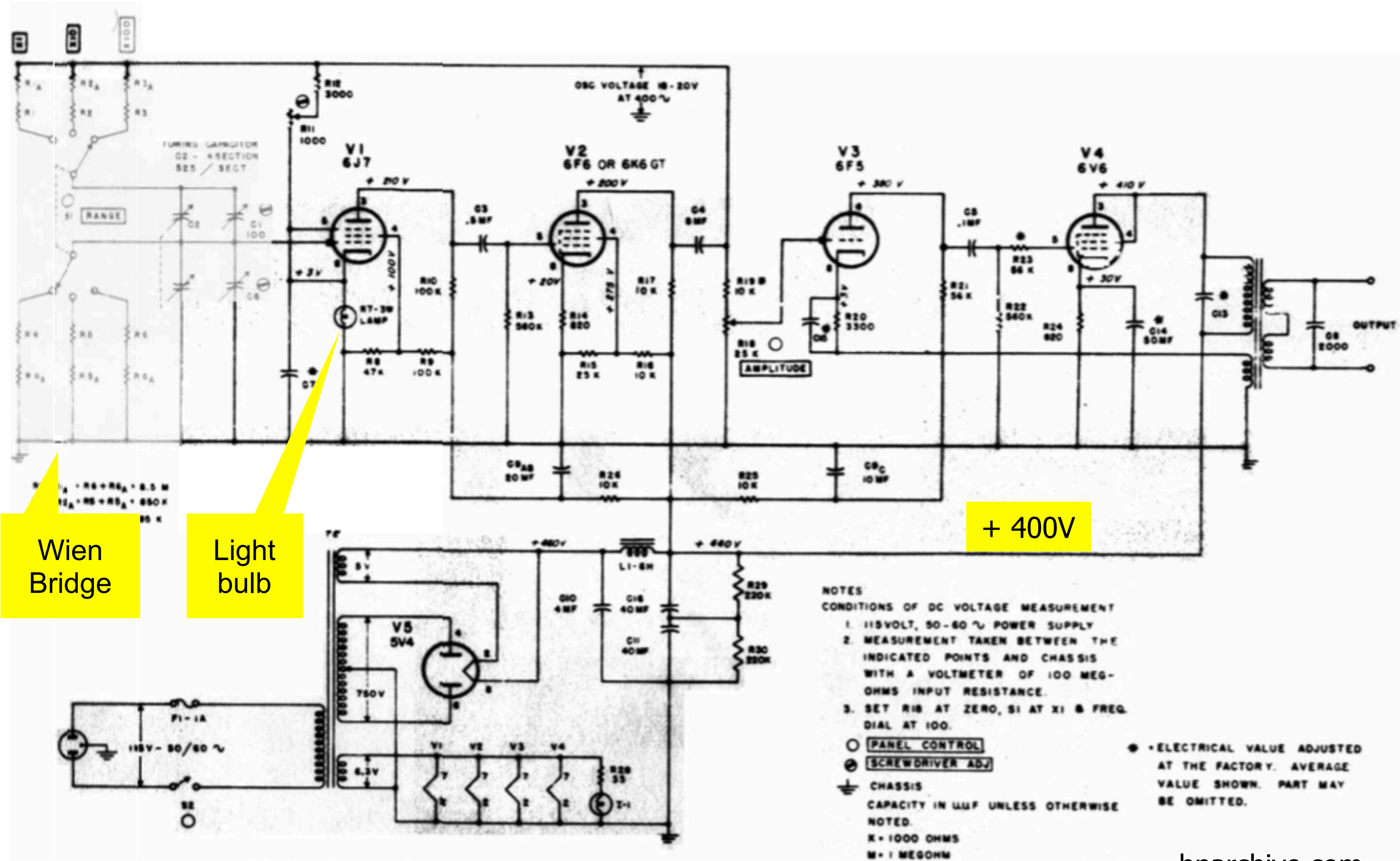
- You can use this 'Wien Bridge' to make an oscillator:
  - Amplify v_{out} by *exactly* 3 (vcvs !) and feed the signal back to v_{in}.
  - Set an initial condition of 1V (parameter!) for the lower C and start a transient simulation.

  - How does this work?
  - What happens if the gain is not exactly 3 ?

Itermezzo: Wien Oszillator

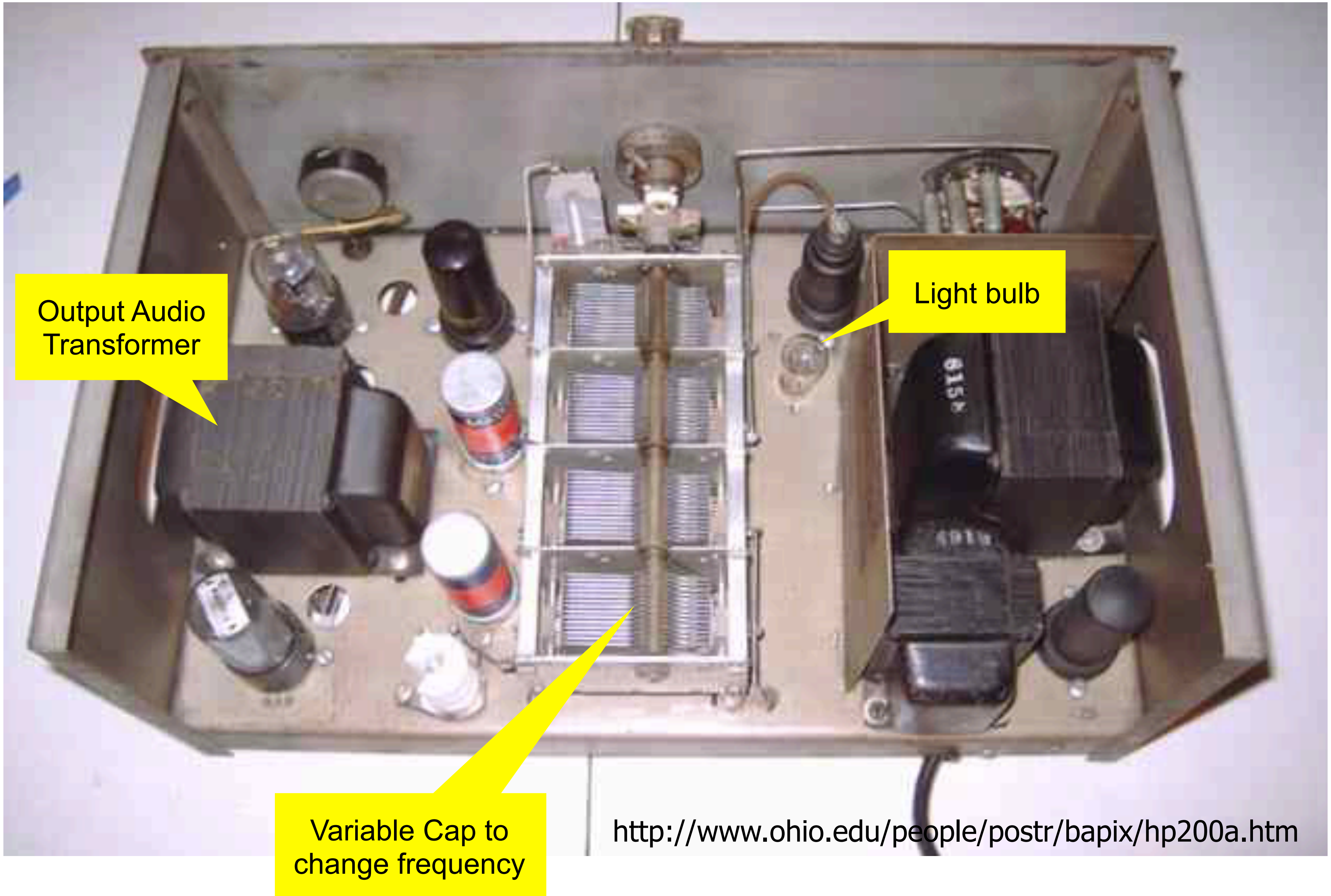
- Wien bridge: Max Wien (1891)
- An Oscillator using a *light bulb* to stabilize gain (leading to with very low distortion) is patented 1939 by William Hewlett and David Packard (Stanford University)
- Founders of Hewlett – Packard (HP)
- Their first product: HP 200A 'Audio Oscillator'

Schematic Diagram (HP 200 B)



hparchive.com

Inside..



http://www.ohio.edu/people/postr/bapix/hp200a.htm

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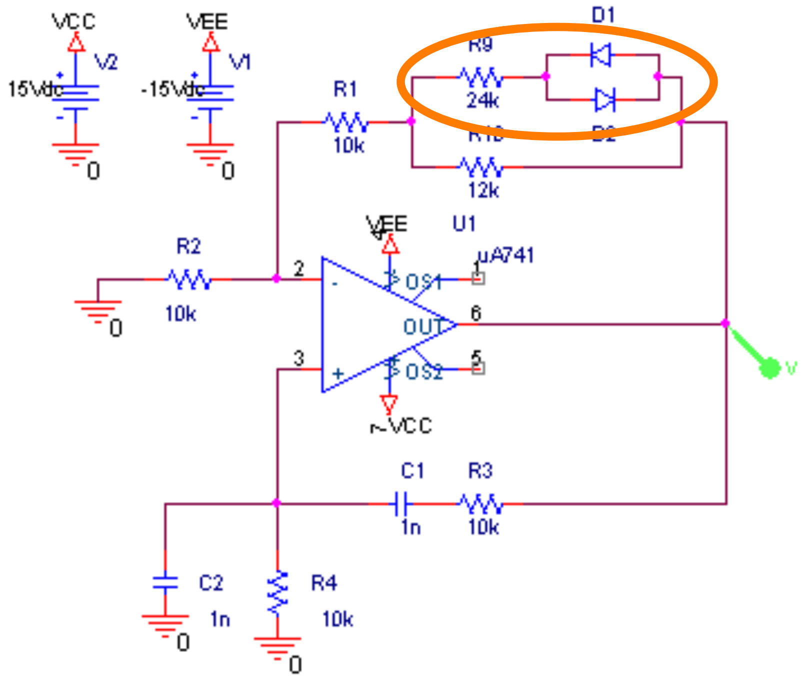
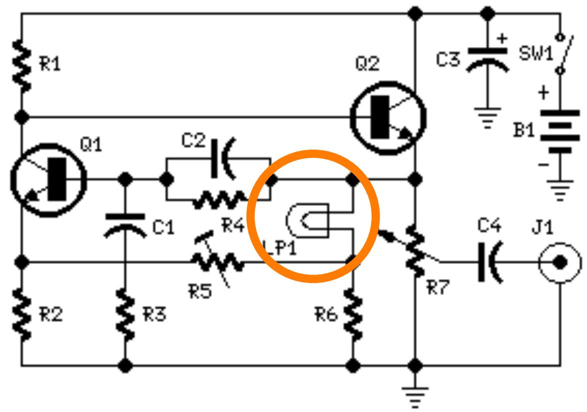
Discrete circuit versions

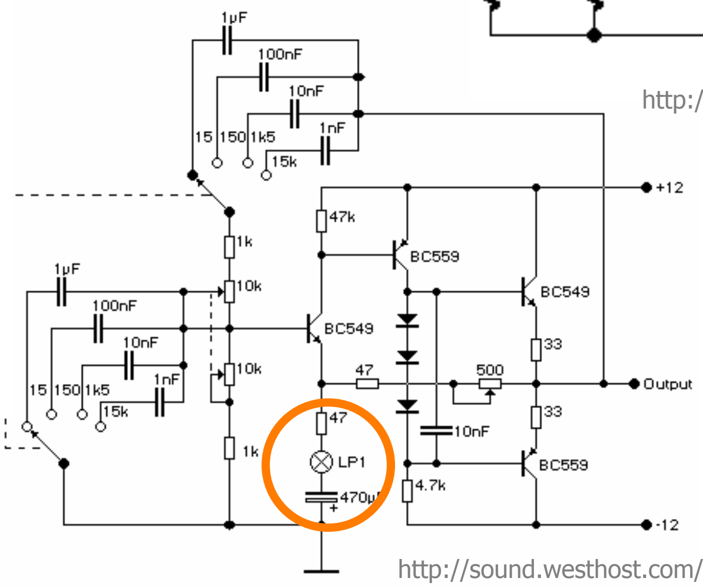
- The problem is to stabilize the gain to exactly 3
- This is achieved by a regulation loop which monitors the output amplitude by some means



www.calvin.edu/~pribeiro/courses/engr332/Handouts



http://www.redcircuits.com//Page13.htm



http://sound.westhost.com/project22.htm