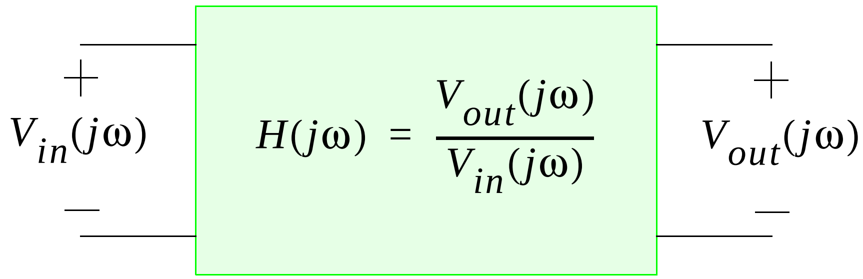
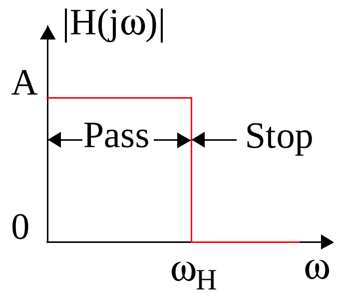
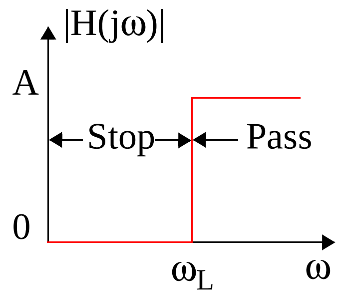
Frequency Responses and Active Filter Circuits

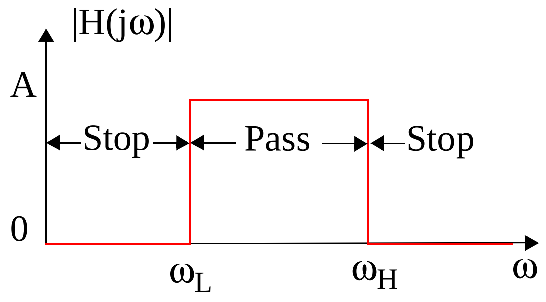
- Compensation capacitors and parasitic capacitors will influence the frequency response
- Capacitors are also purposely added to create certain functions; e.g. integrators
- The most common use of energy storage elements in opamp circuits is for filtering
- Inductors are not as often used as capacitors because they are much bulkier and more difficult to integrate on an IC
- The order of the filter depends on the number of energy storage elements that are used

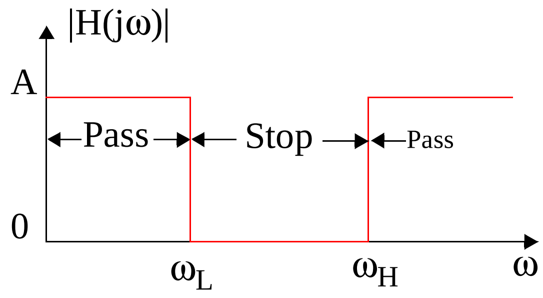
Ideal Filters





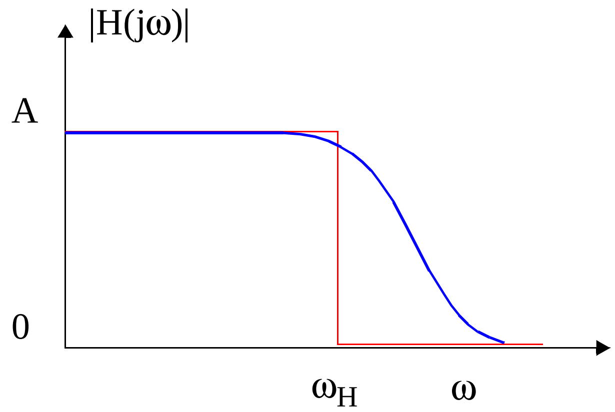




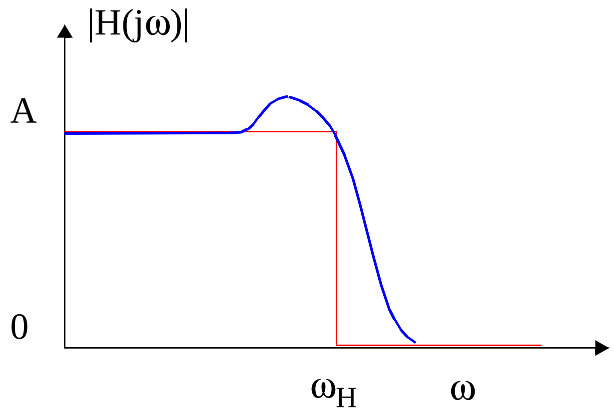


Ideal Filters

- We know that a first order filter will not look like an ideal model:

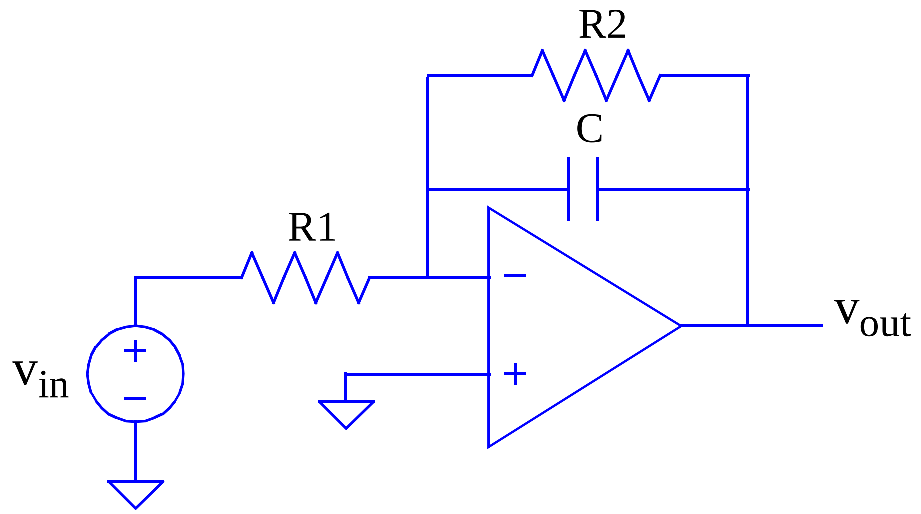


- Higher order filters will attempt to have sharper transitions at the cut-off frequencies, but sometimes at the expense of increased ripple



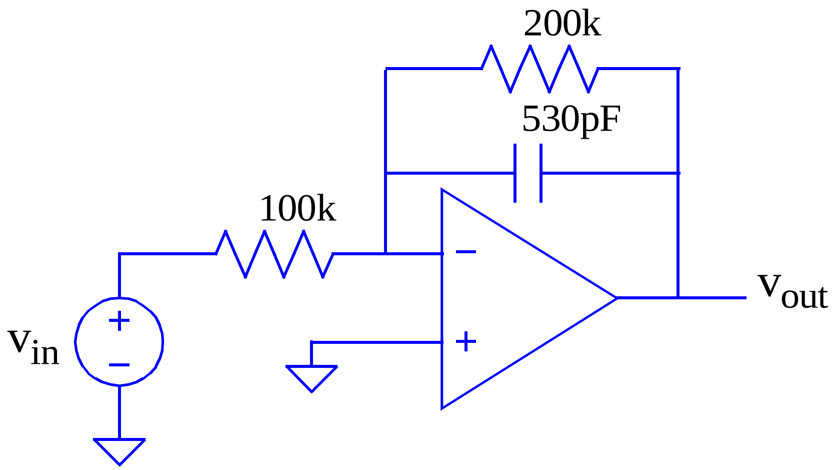
First-Order Low Pass Filter

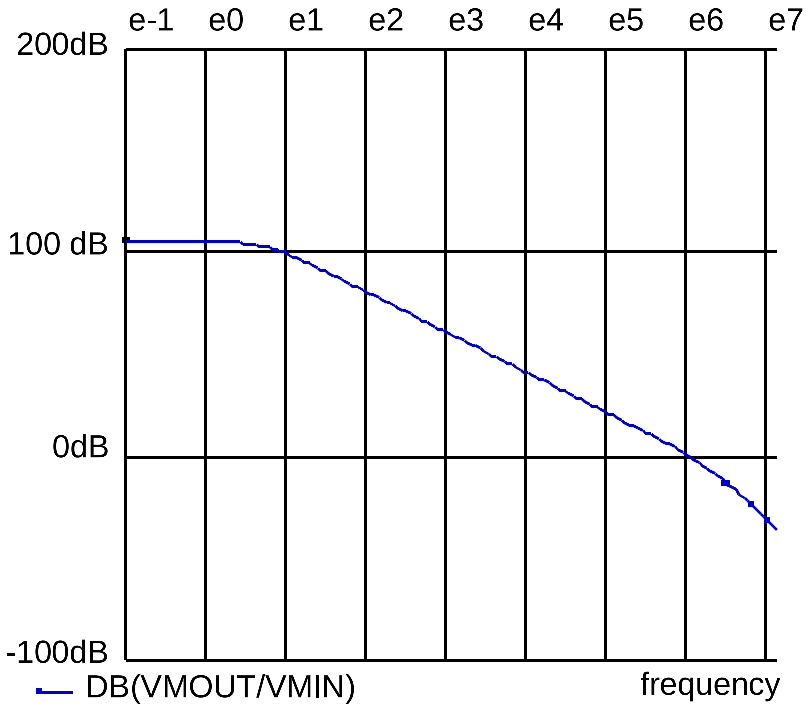
- Design for a 3dB cut-off frequency of 3000π (radians/second), a dc gain of 2, and an input impedance of at least 100kΩ



First-Order Low Pass Filter

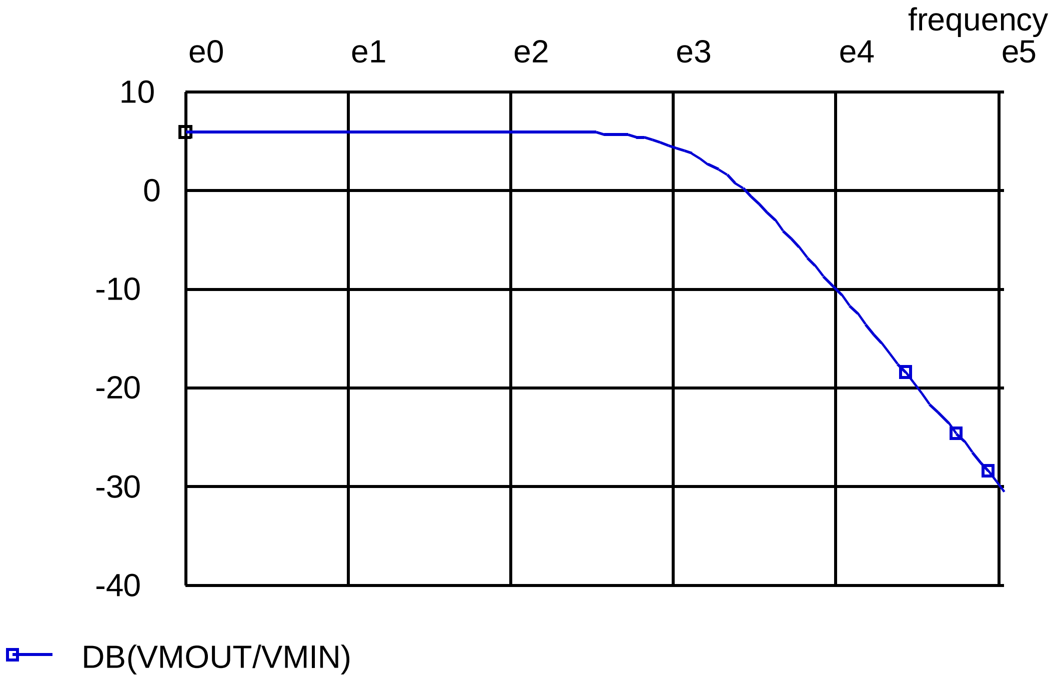
- Will the frequency dependence of the open loop gain present a problem for this circuit using a 741 opamp?





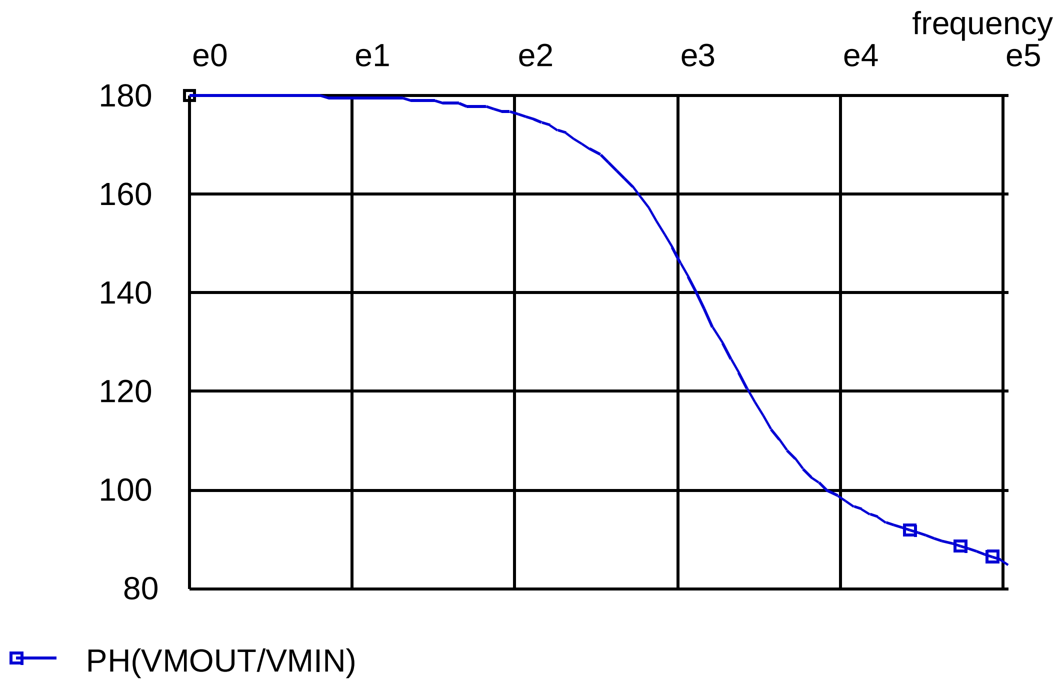
First-Order Low Pass Filter

- SPICE results for magnitude using 741 opamp model



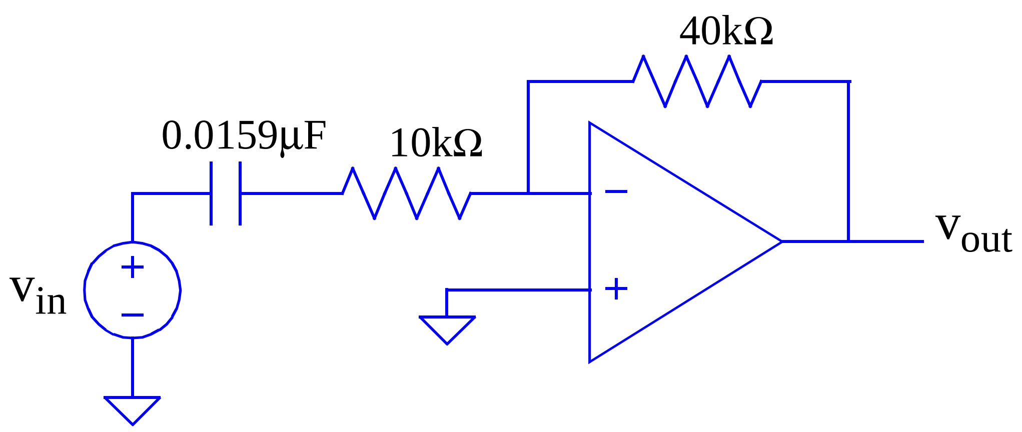
First-Order Low Pass Filter

- SPICE results for phase using 741 opamp model



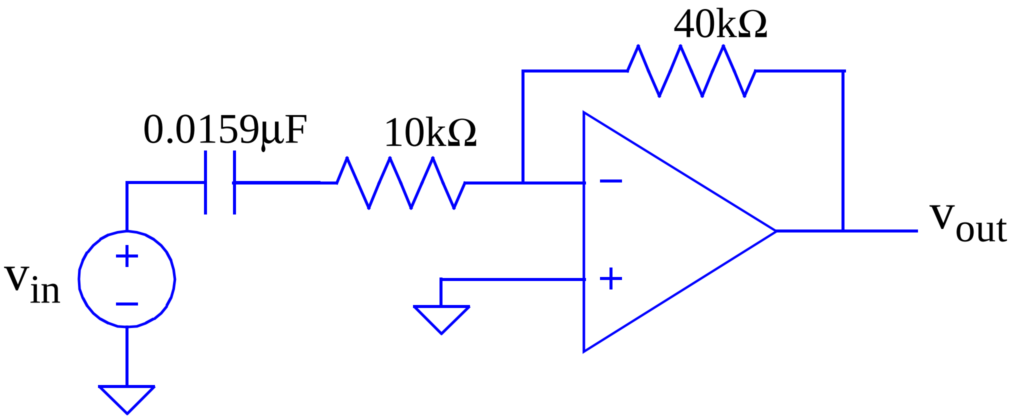
First-Order High Pass Filter

- Calculate a transfer function to approximate the cut-off frequency



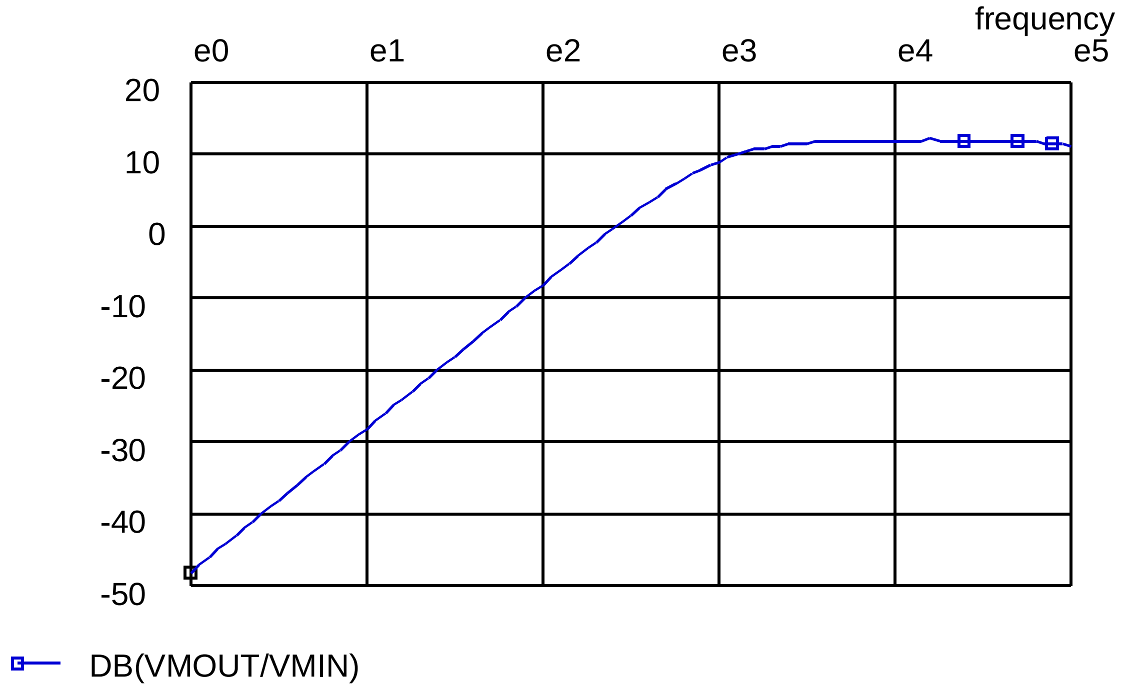
First-Order High Pass Filter

- What is the high frequency gain for this circuit?



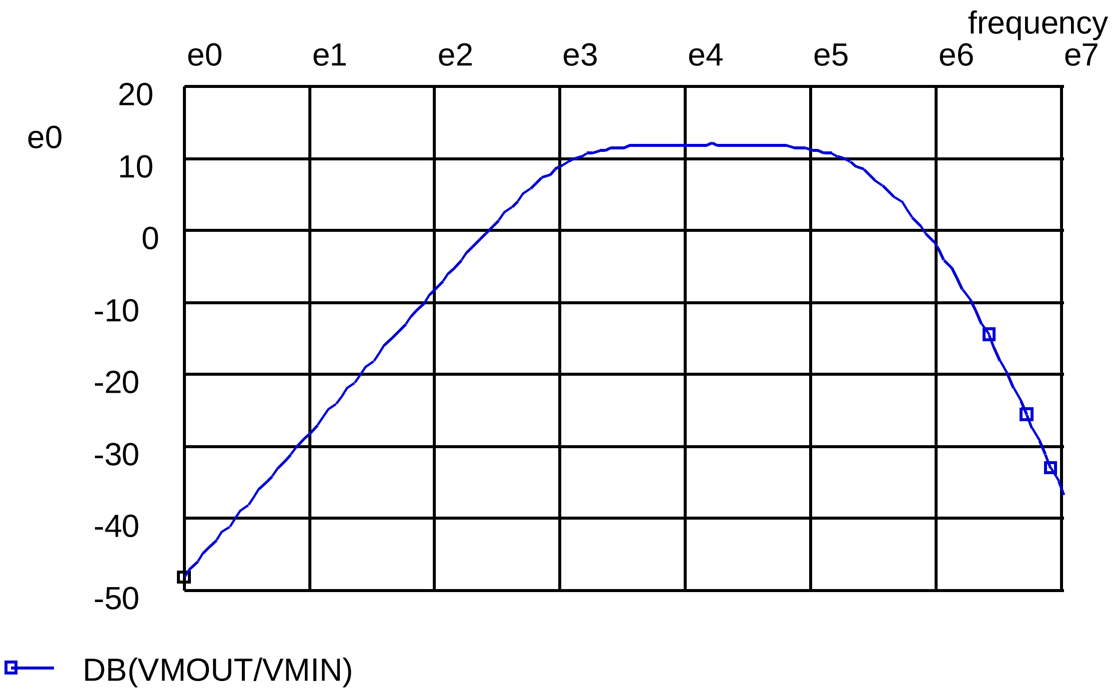
First-Order High Pass Filter

- SPICE results for magnitude using 741 opamp model



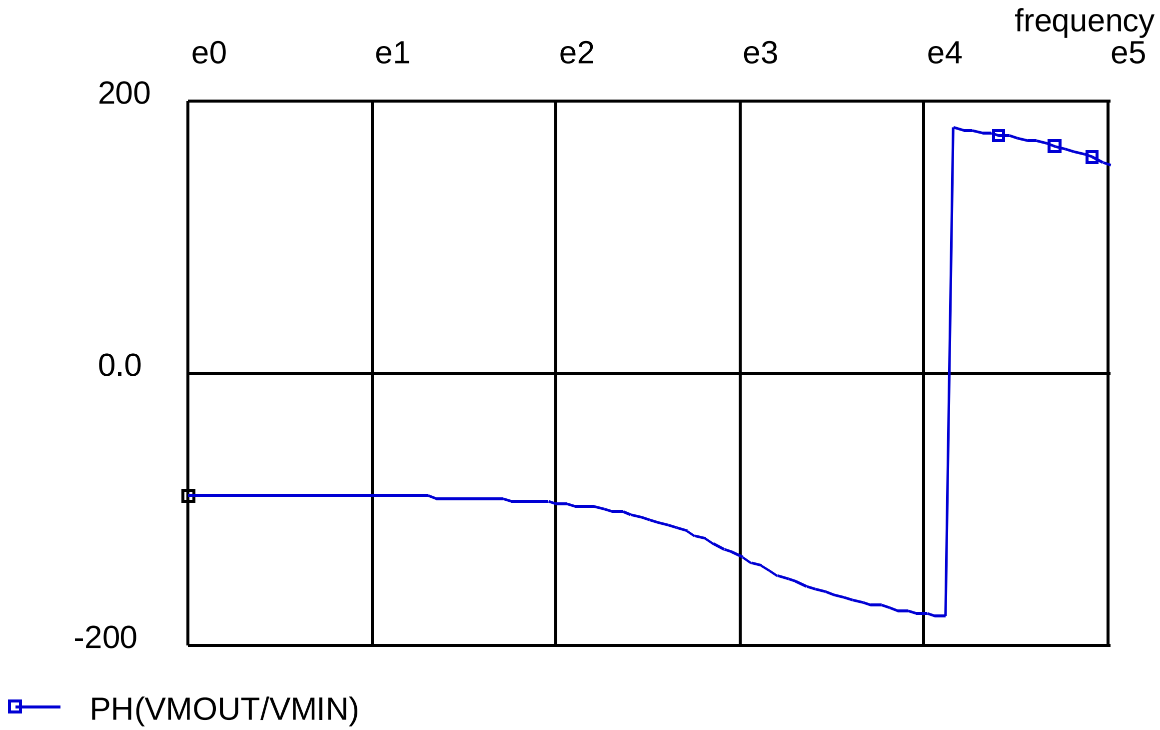
First-Order High Pass Filter

- Note that the low-pass nature of the opamp makes this high-pass filter a band-pass filter when using a 741-type opamp



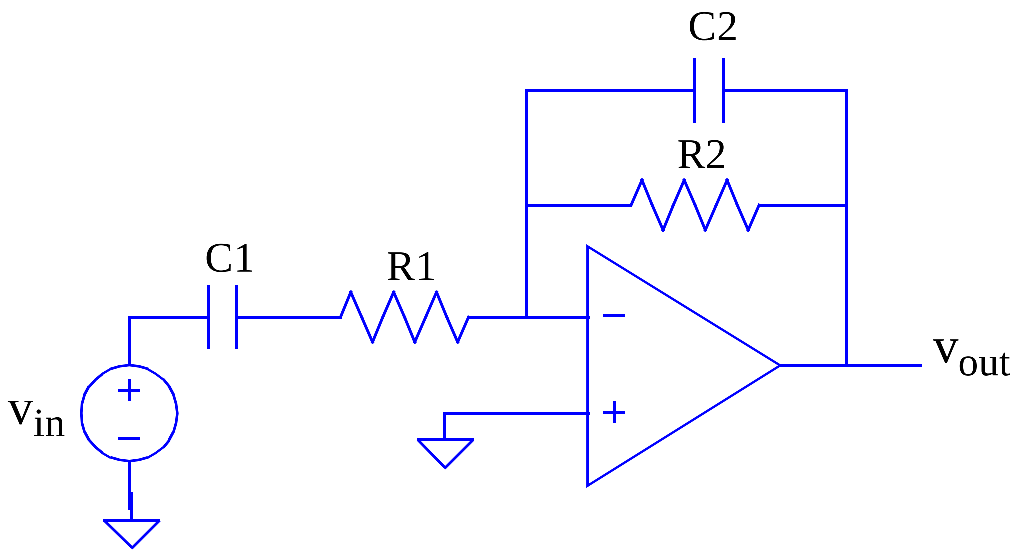
First-Order High-Pass Filter

- SPICE results for phase using 741 opamp model
- Why the discontinuity?

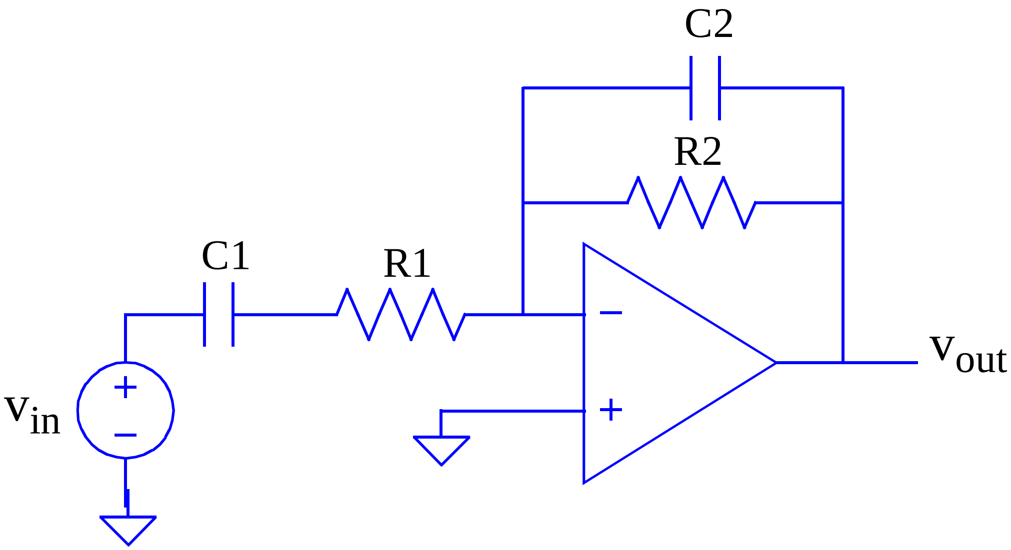


Band Pass Filter

- Design for a mid-band frequency gain of 5 (volts/volt), and f_L=500Hz and f_H=5kHz.

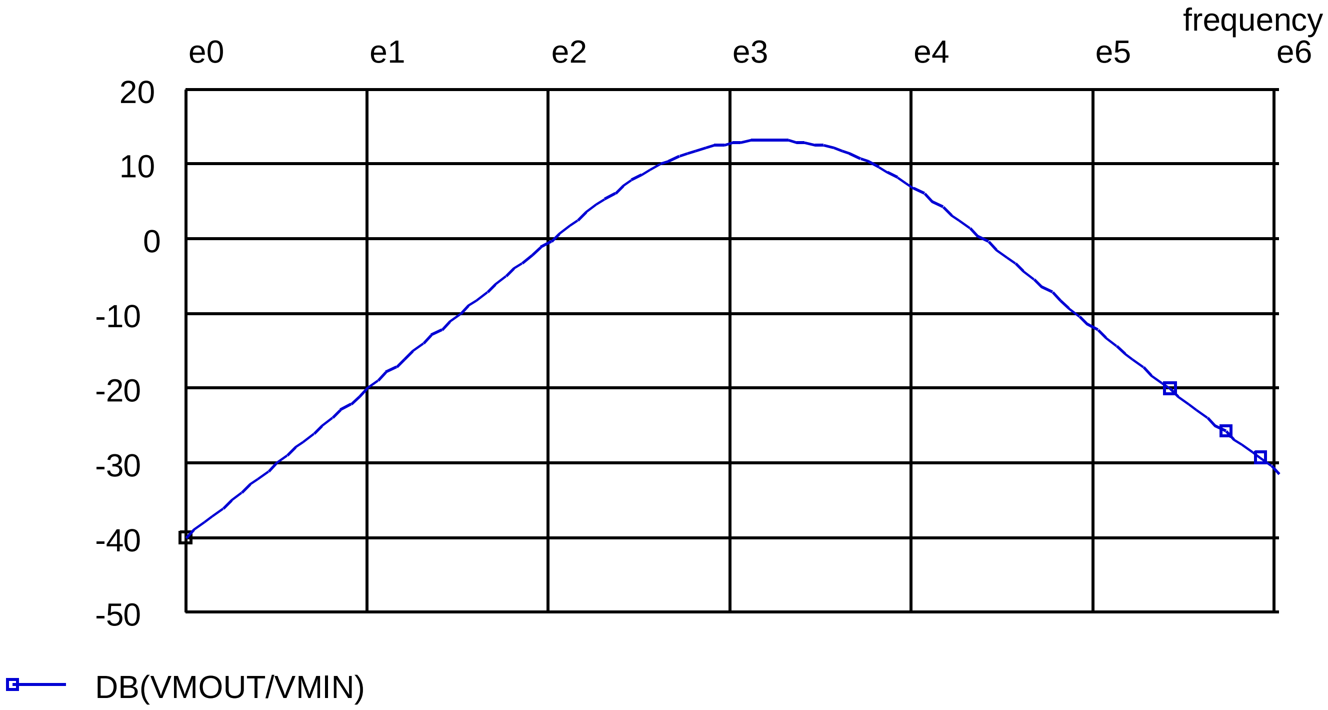


Band-Pass Filter



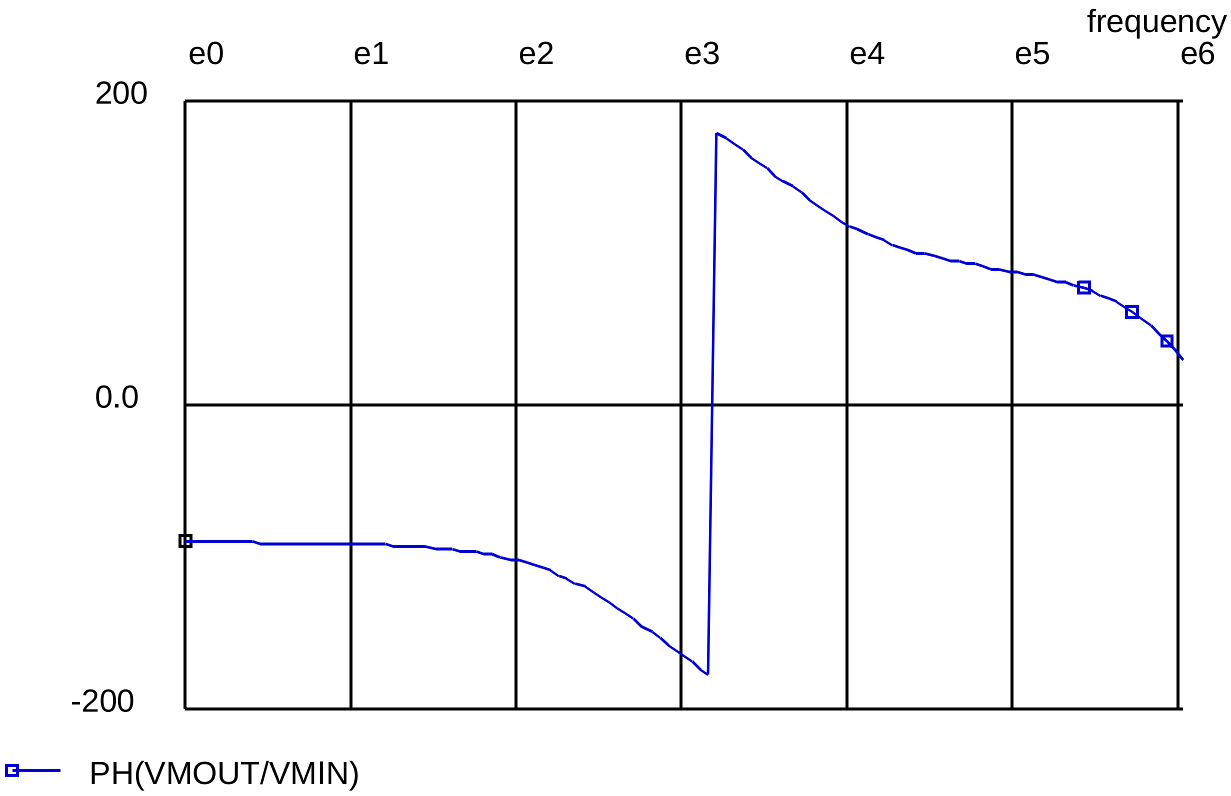
Band Pass Filter

- SPICE results for magnitude using 741 opamp model



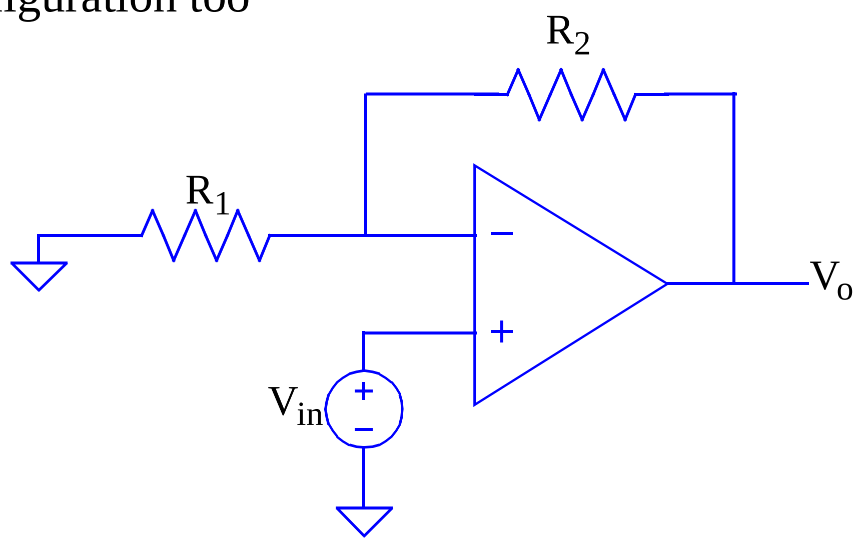
Band-Pass Filter

- SPICE results for phase using 741 opamp model



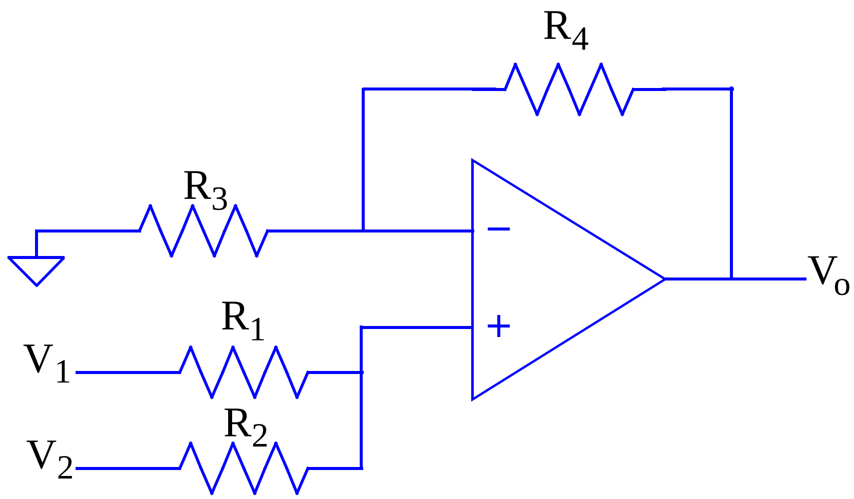
Noninverting Opamp

- Most of the circuits that we've seen so far can also be designed in a non-inverting configuration too



Other Noninverting Configurations

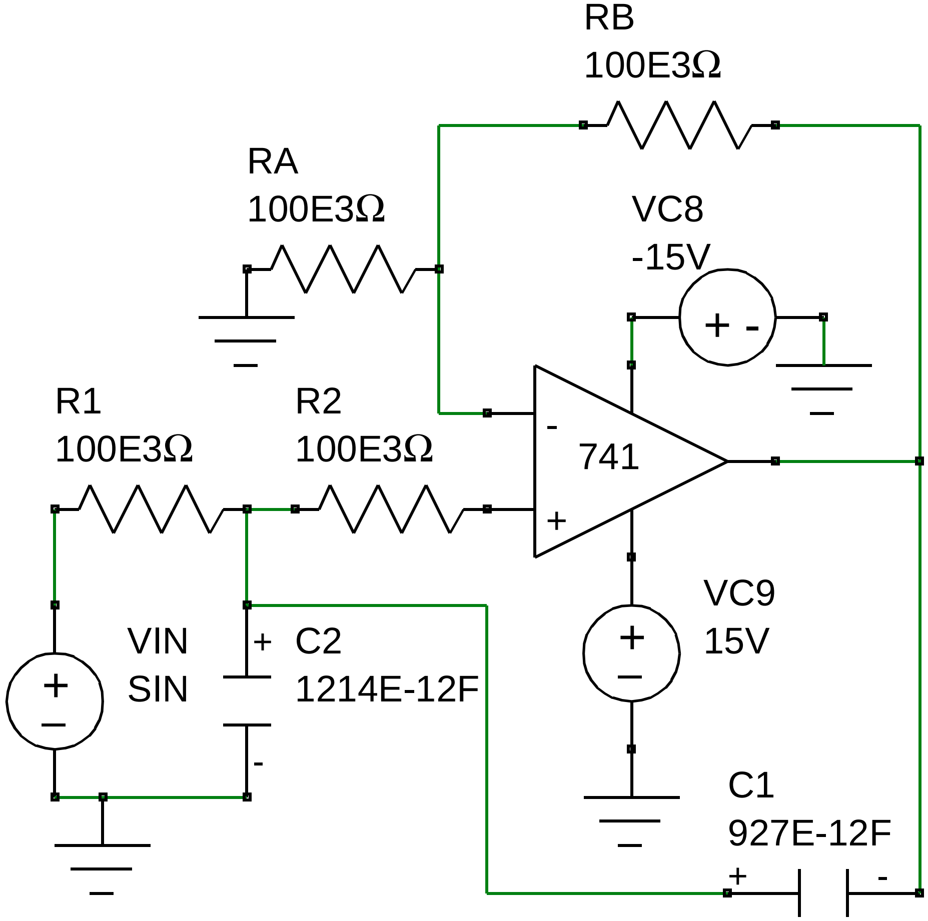
- But sometimes they are a bit trickier to solve
- What is the transfer function of this circuit? How is it best evaluated?



Second-Order Low Pass Filter

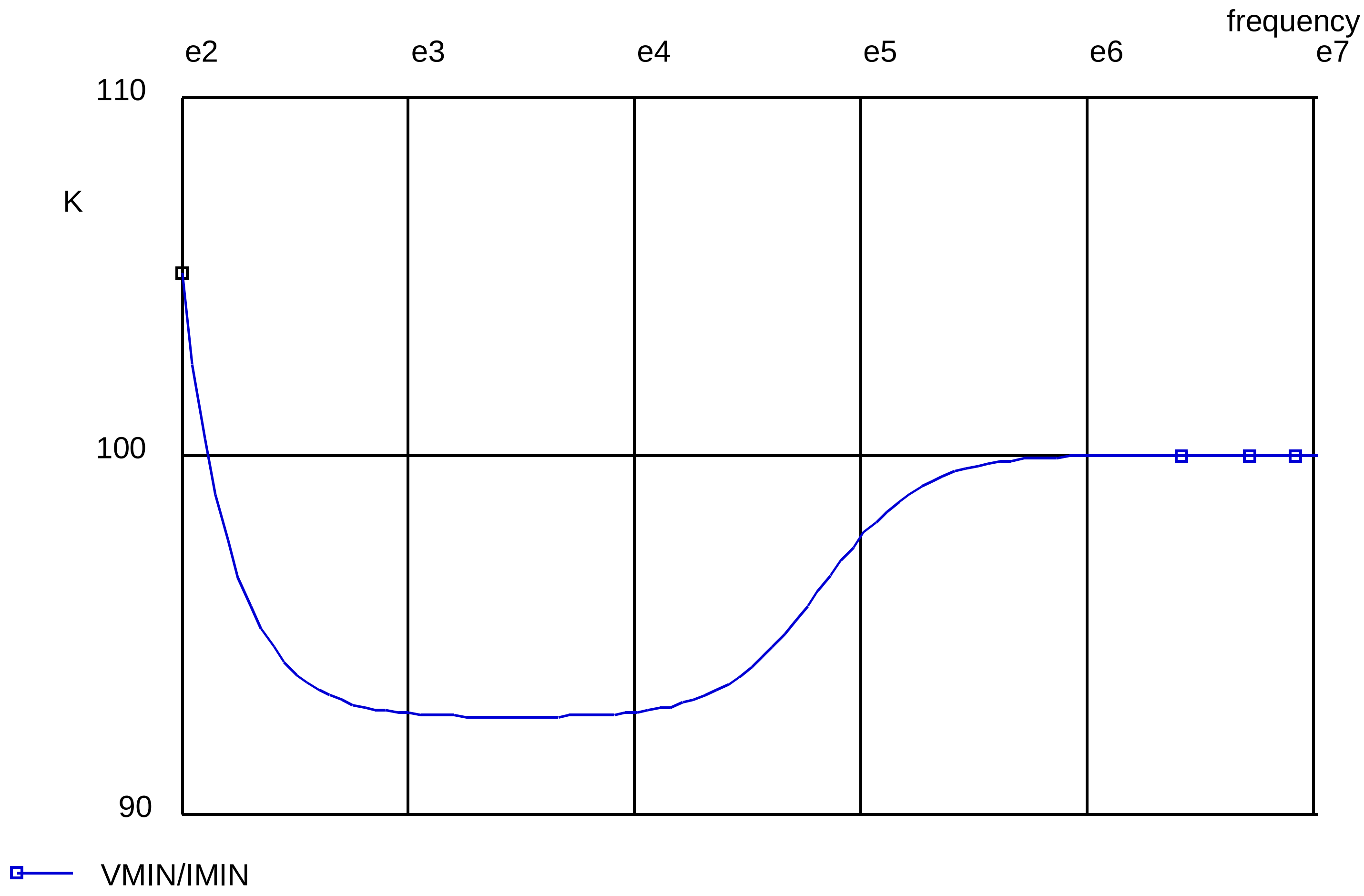
- Design for a 3dB cut-off frequency of 3000π (radians/second), a dc gain of 2, and an input impedance of 100kΩ

Suggested configuration and element values from a book



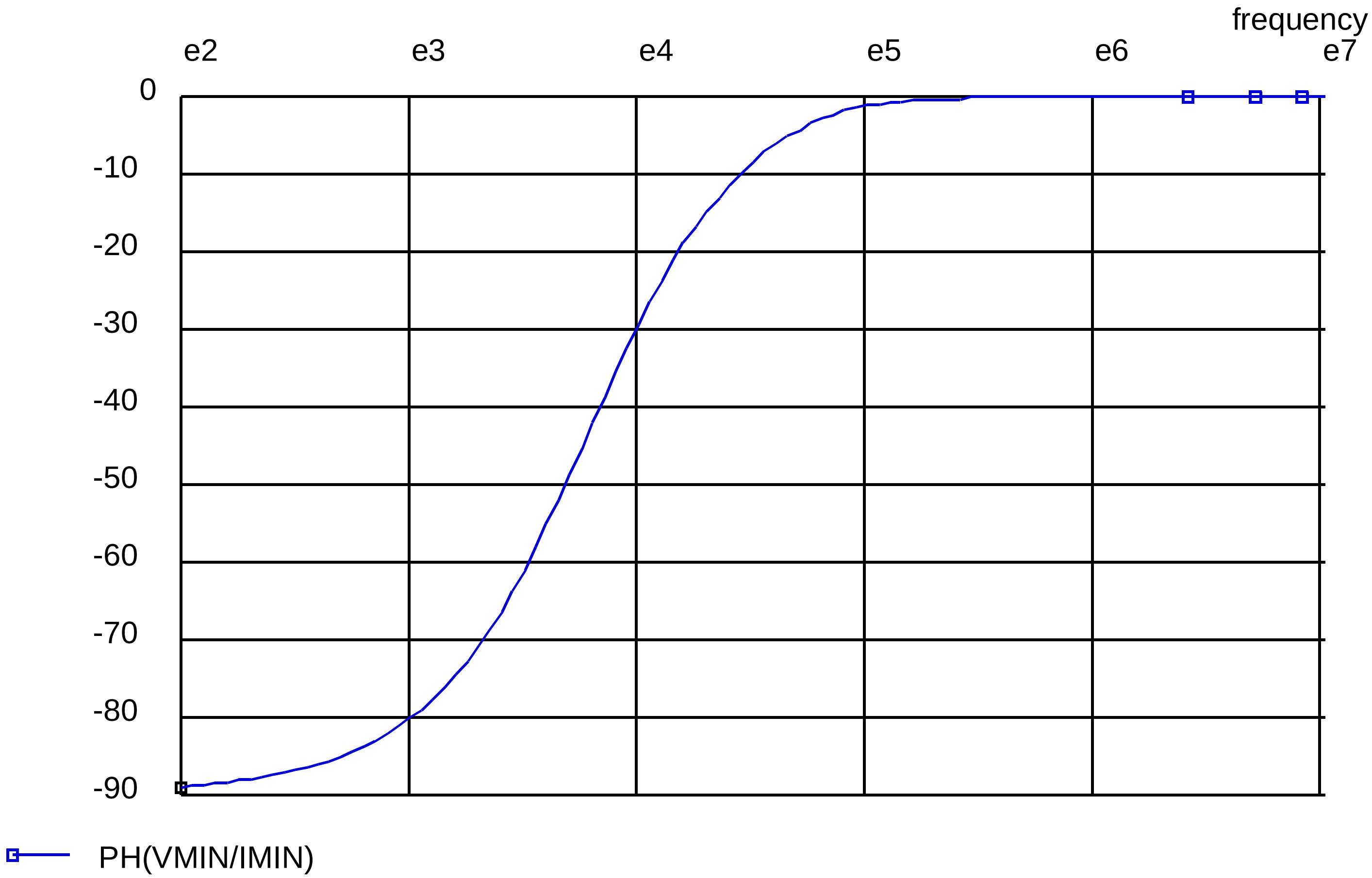
Second-Order Low Pass Filter

- SPICE results for magnitude using 741 opamp model
- Input impedance "magnitude" as a function of frequency



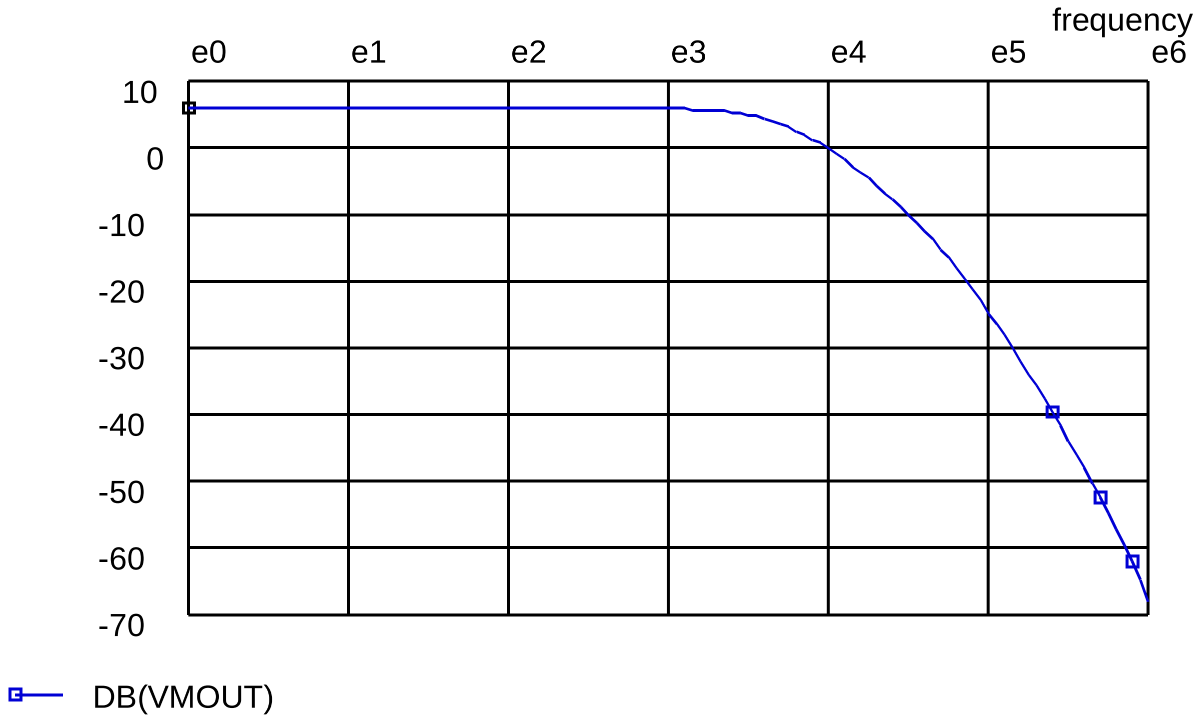
Second-Order Low Pass Filter

- Input impedance "phase" as a function of frequency



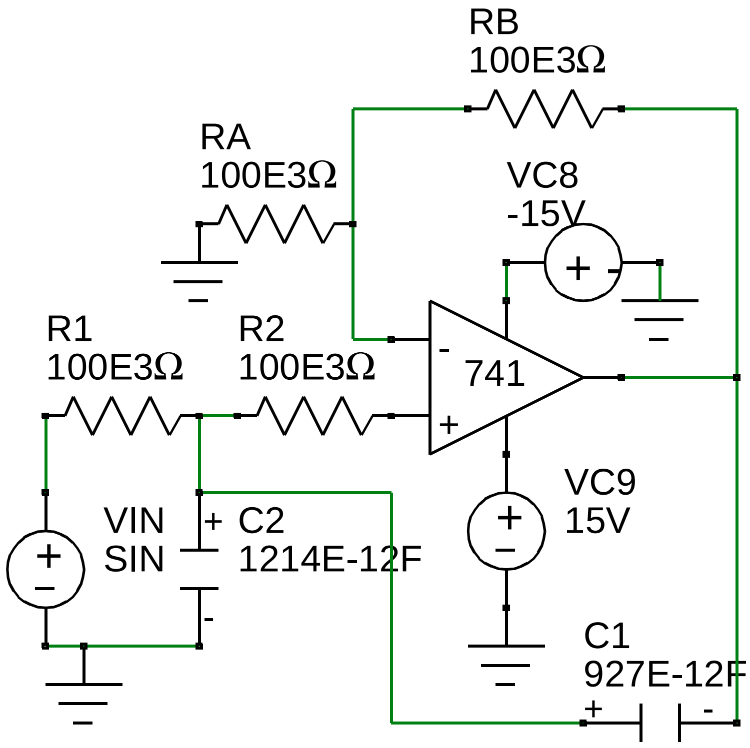
Second-Order Low Pass Filter

- SPICE results for magnitude using 741 opamp model
- Fall-off is sharper for higher frequencies, but 3dB point is at 5.6kHz



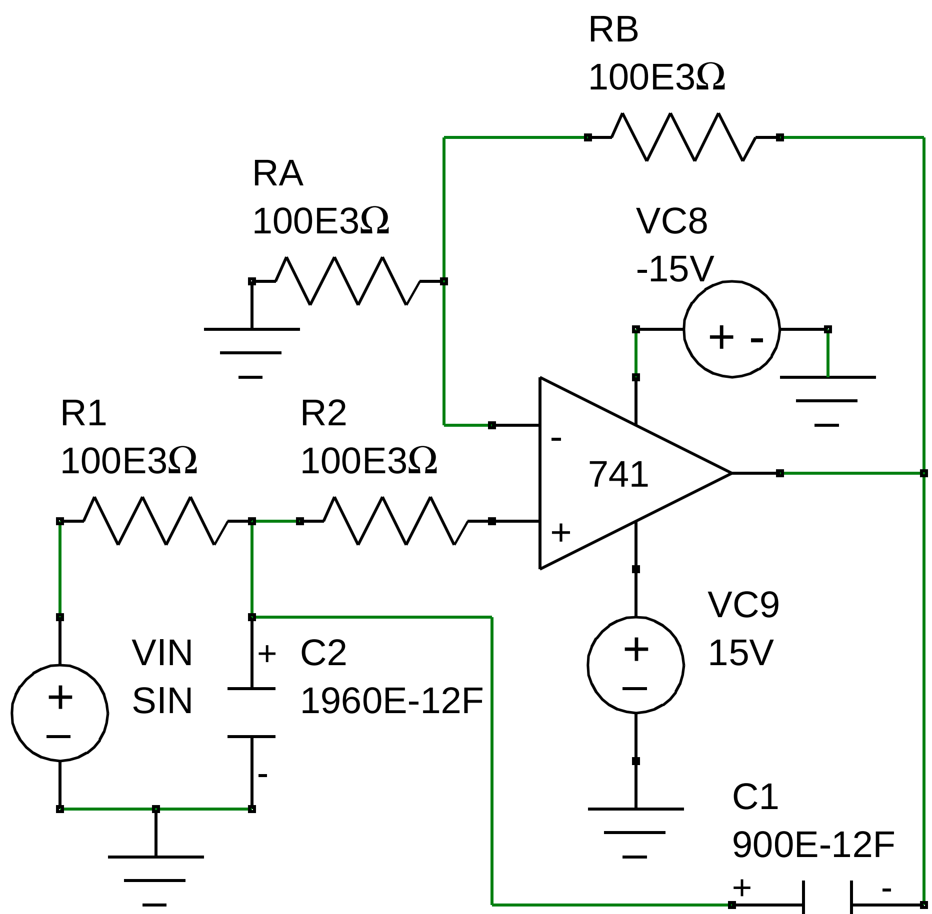
Second-Order Low Pass Filter

- 3dB cut-off frequency is slightly off from 1.5kHz target
- What parameters do we change to lower it 3dB slightly?



Second-Order Low Pass Filter

- Design for a 3dB cut-off frequency of 3000π (radians/second), a dc gain of 2, and an input impedance of 100kΩ using values determined by pole analysis



Second-Order Low Pass Filter

3dB is now at 1.5kHz