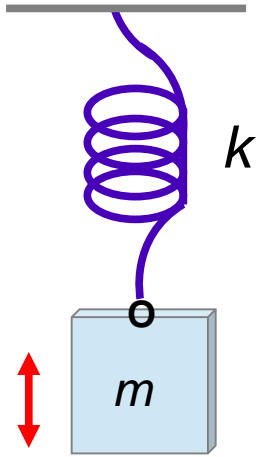
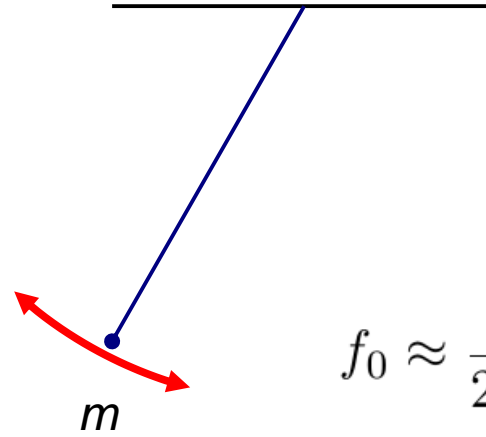


Lab 10: Oscillators

Oscillators



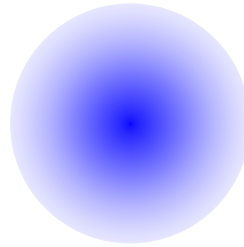
$$f_0 = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$



$$f_0 \approx \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

Oscillators

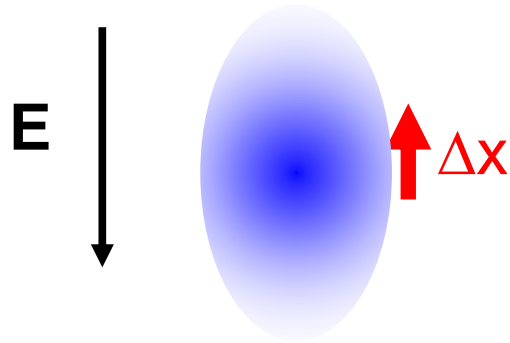
Lorentz Model of the atom



Nucleus + electron cloud

Oscillators

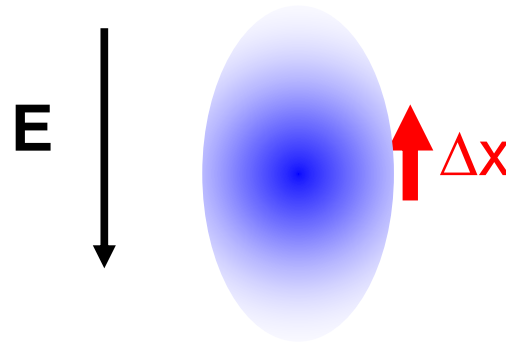
Lorentz Model of the atom



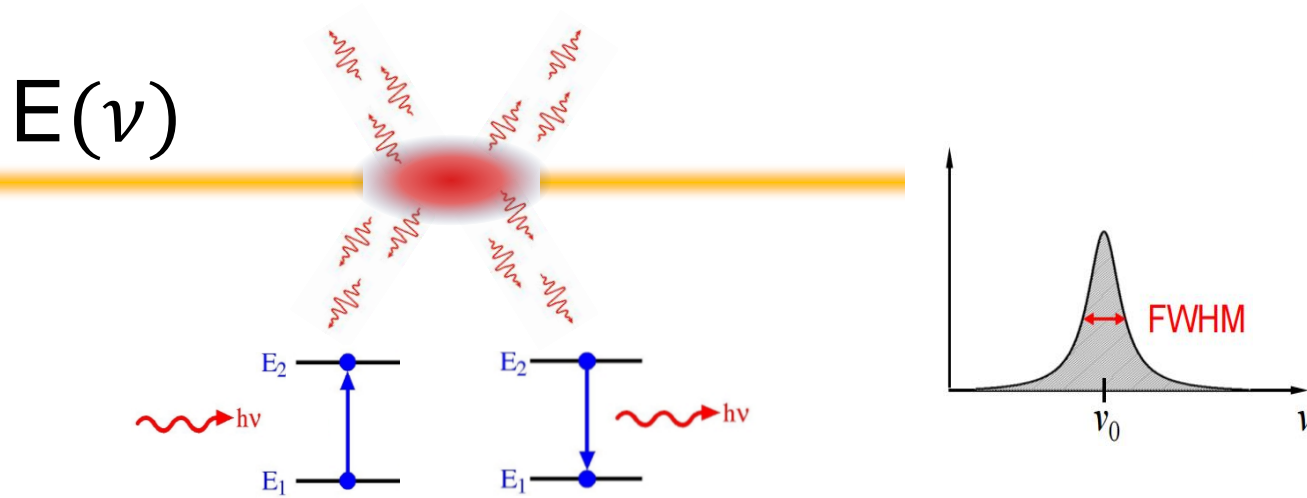
Electric-field induces a dipole moment

Oscillators

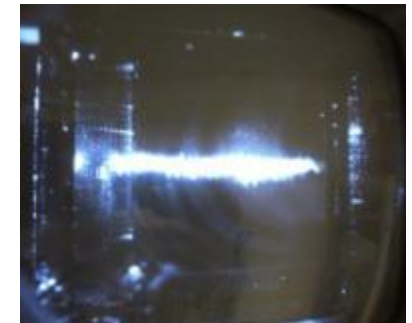
Lorentz Model of the atom



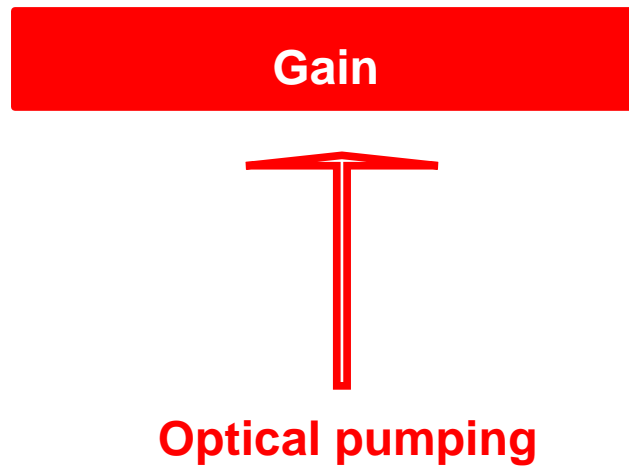
Atoms driven on resonance:



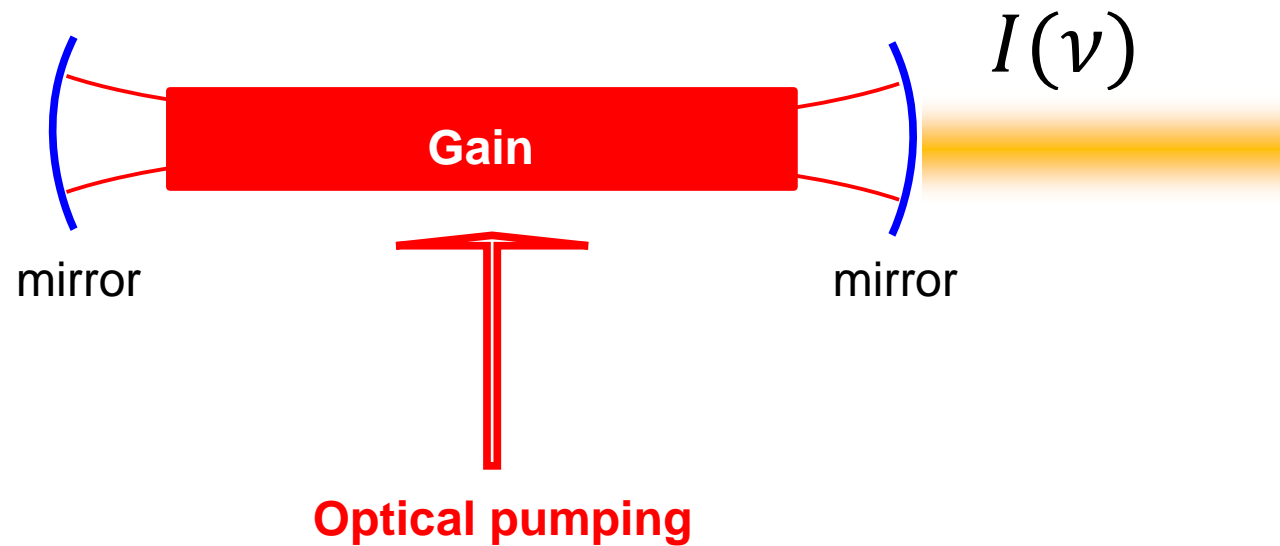
Laser-Cooled Cesium Atoms



Laser Oscillators: Optical gain inside a feedback cavity

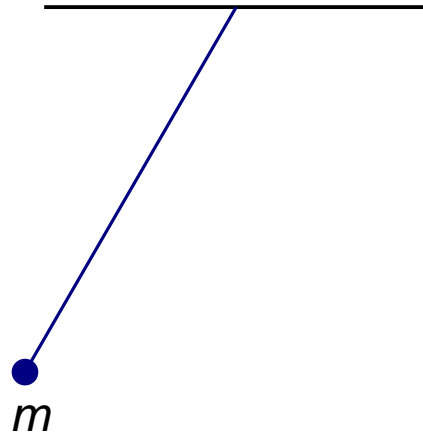


Laser Oscillators: Optical gain inside a feedback cavity



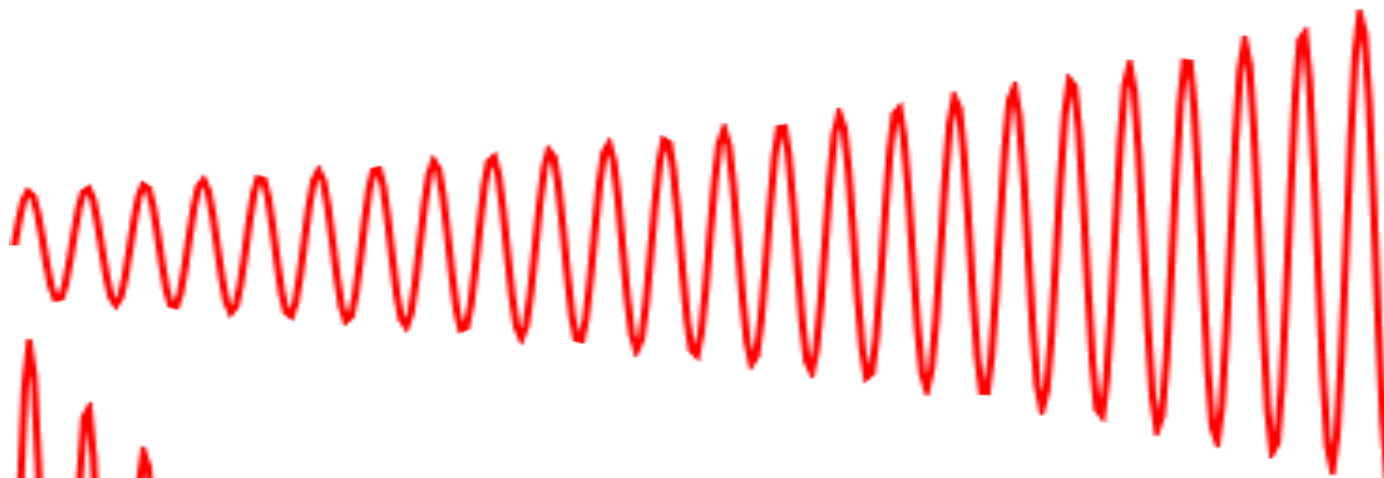
- *Excitation & Amplification*
- *Feedback*
 ➔ *Oscillation*

Driven oscillations: Pendulum example

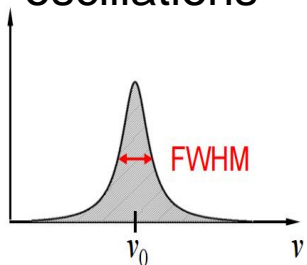
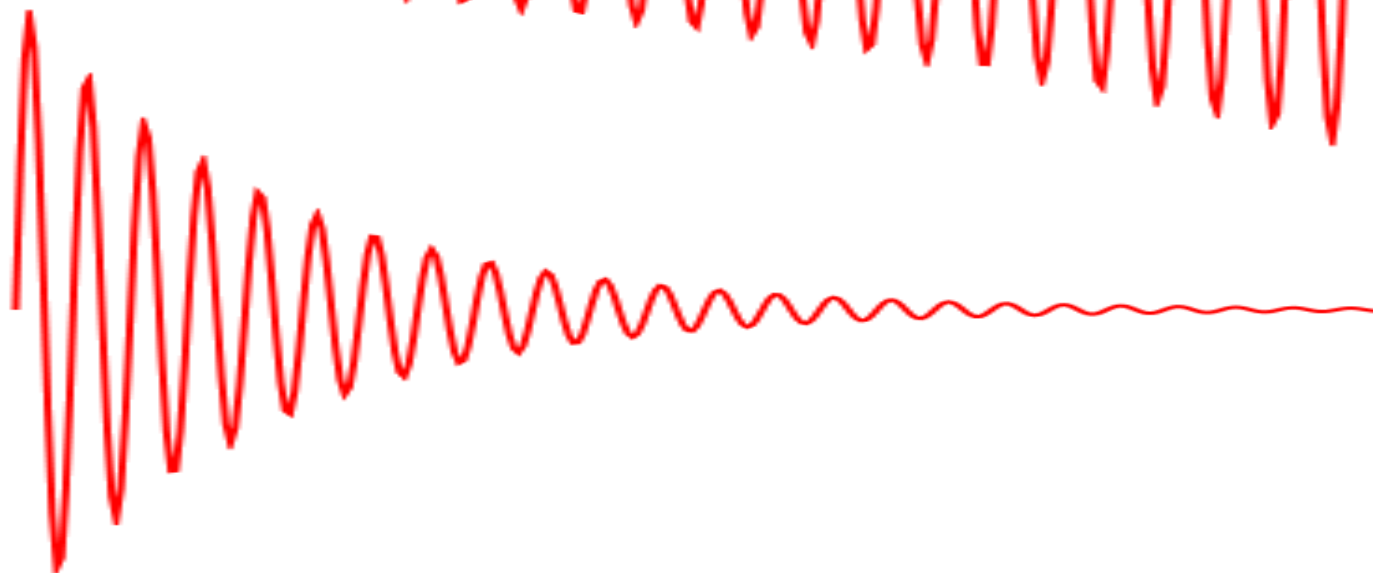


$$f_0 \approx \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

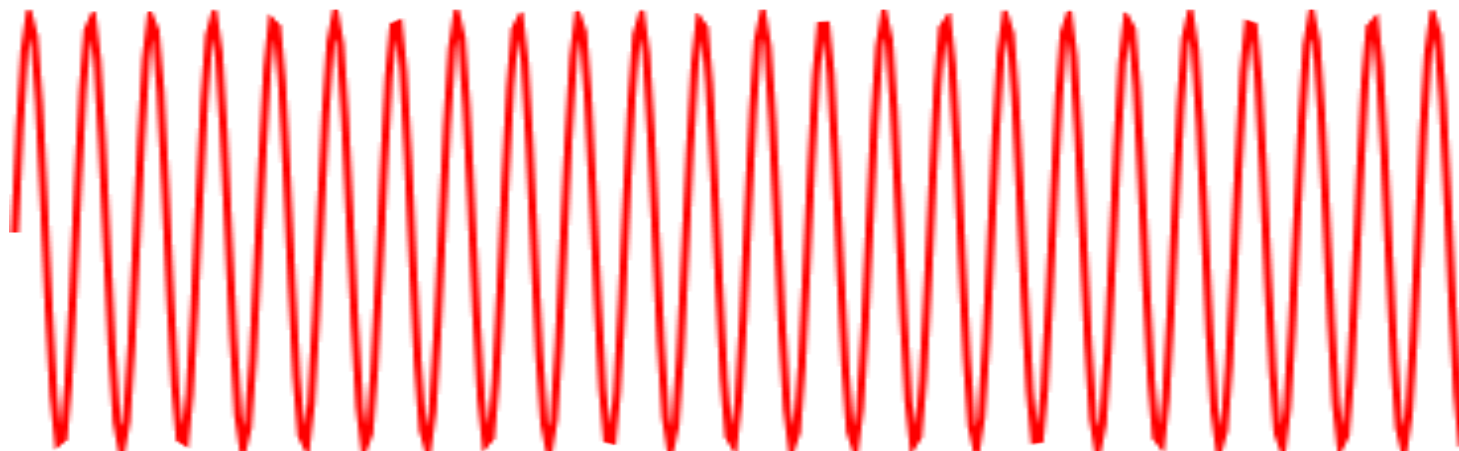
Under-damped
driven oscillations



Damped
oscillations

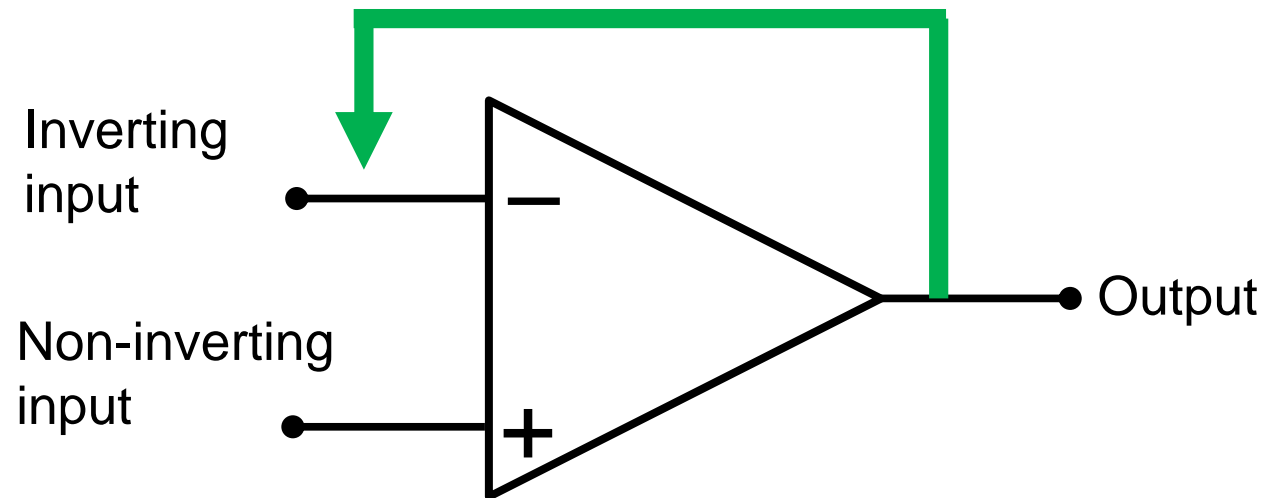


Stable
oscillations



FEEDBACK: Sending a portion of the output back to the input

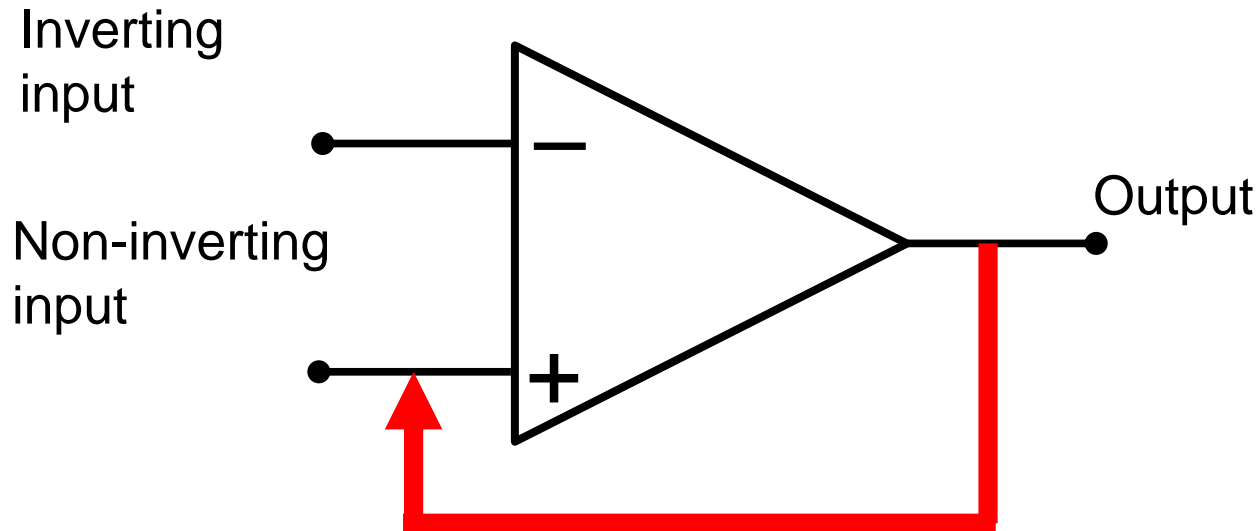
Negative feedback



Stabilizes the output of an amplifier

FEEDBACK: Sending a portion of the output back to the input

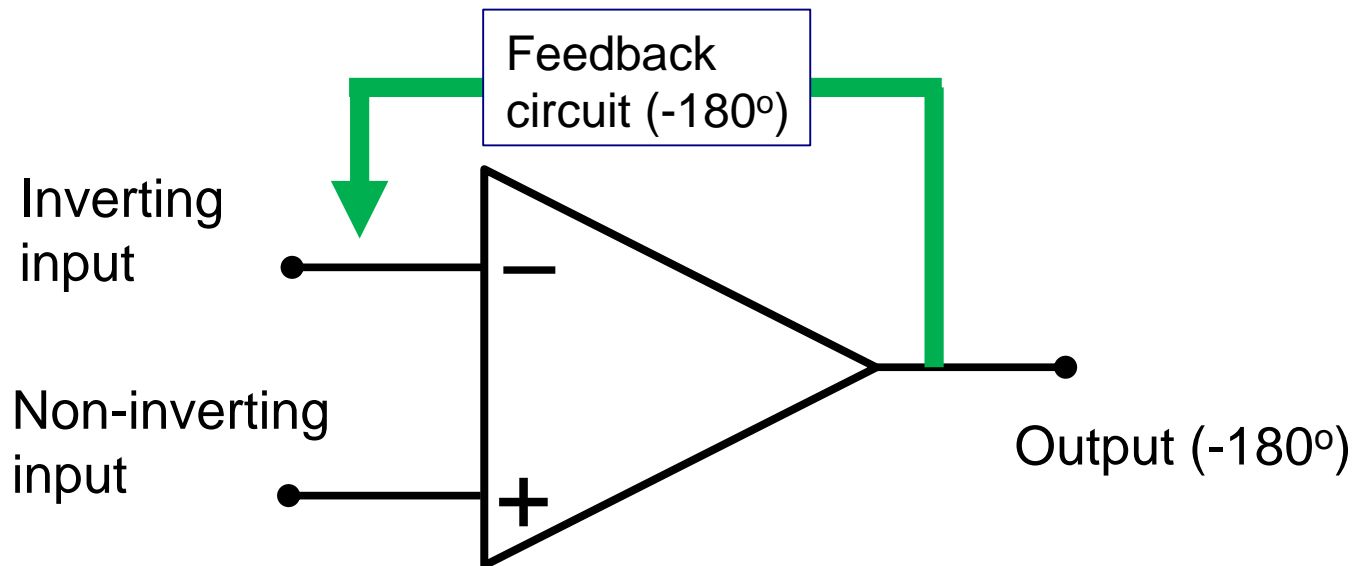
Positive feedback



Runaway amplification – Oscillation

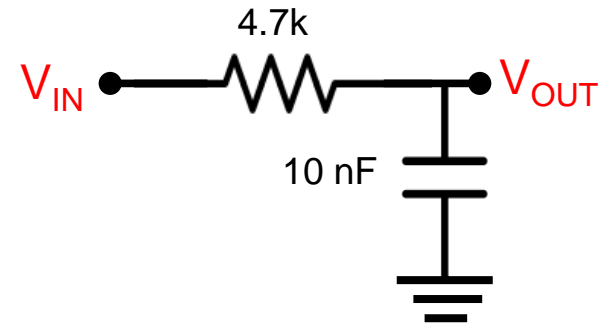
Stable oscillations using the inverting input

- 1) Net gain is 1.
- 2) Phase-shift between input-output is 0.

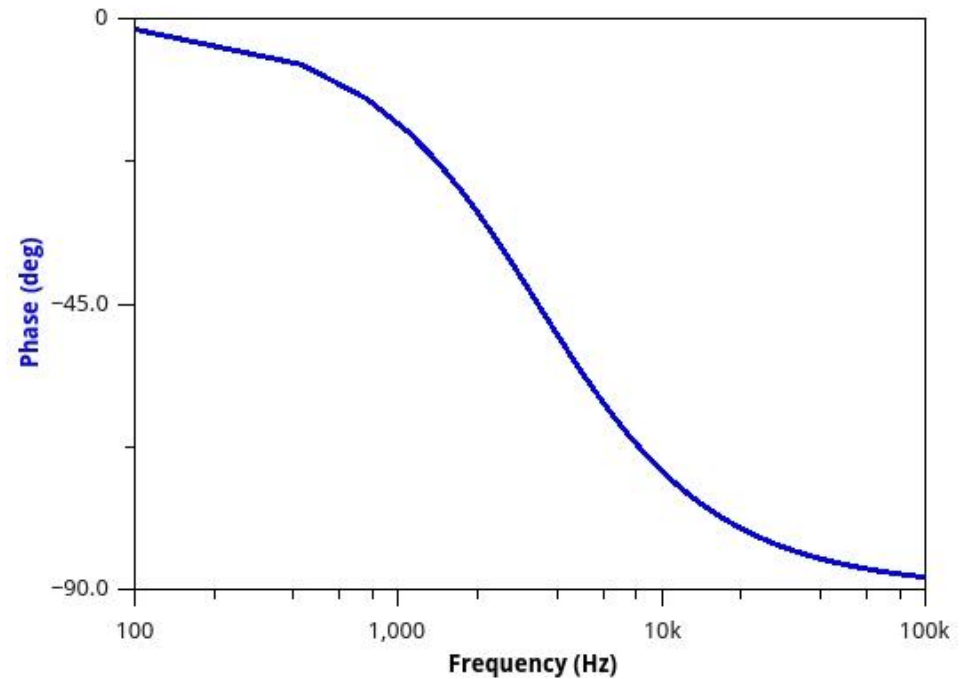
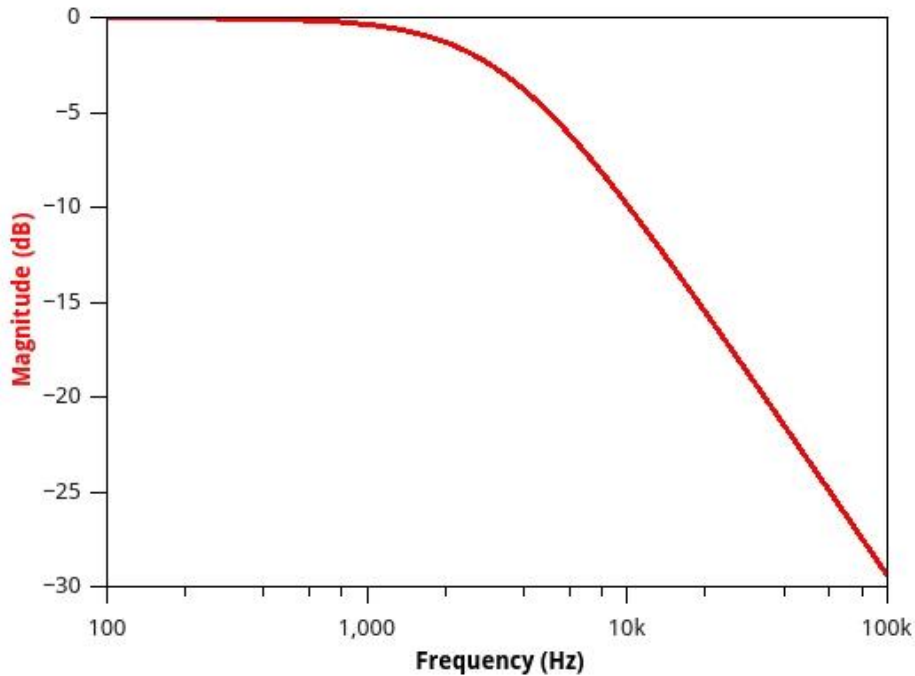


Single RC filter provides phase shift but not enough for oscillation

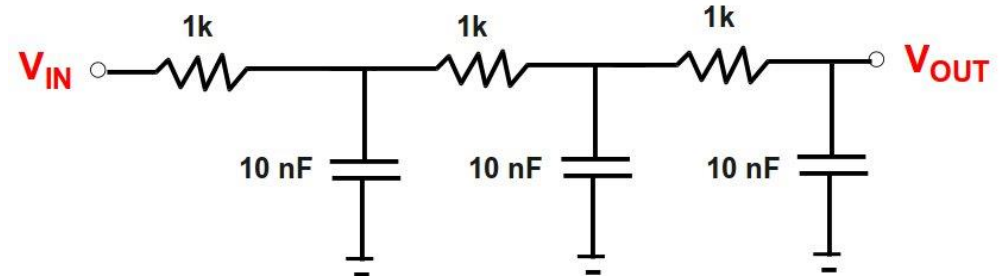
Need -180°



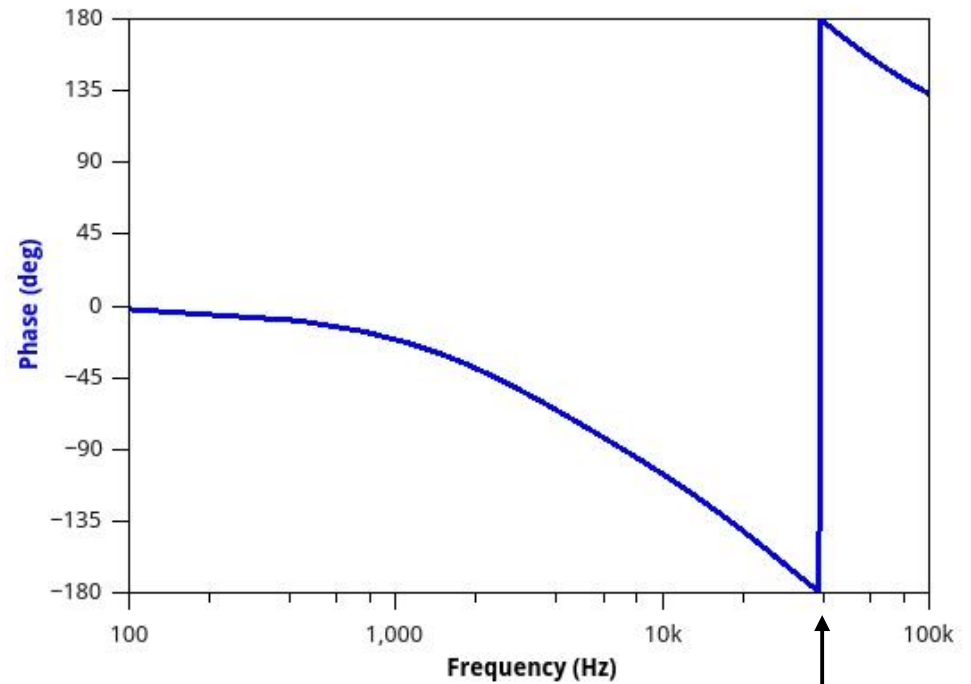
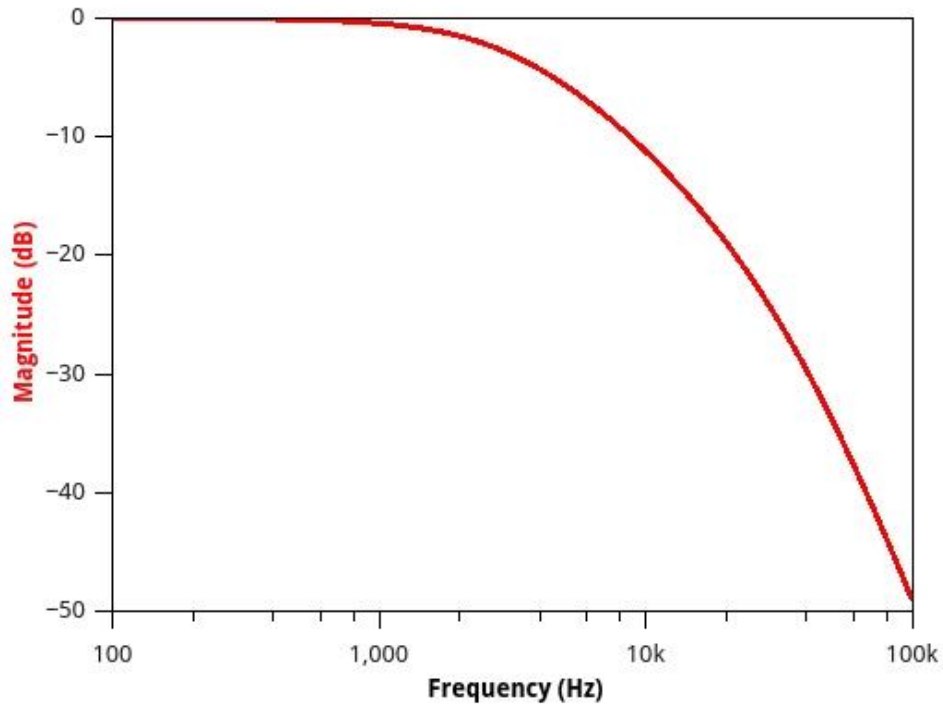
Bode plots of **Magnitude** and **Phase** for single RC low-pass filter



3-Stage RC network provides adequate feedback phase-shift for oscillations

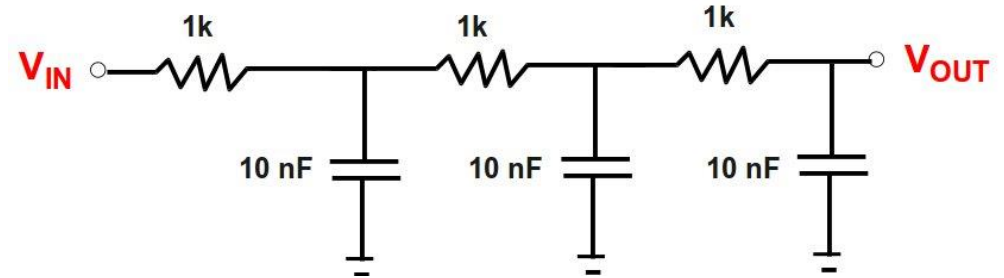


Bode plots of **Magnitude** and **Phase** for 3-stage RC low-pass filter

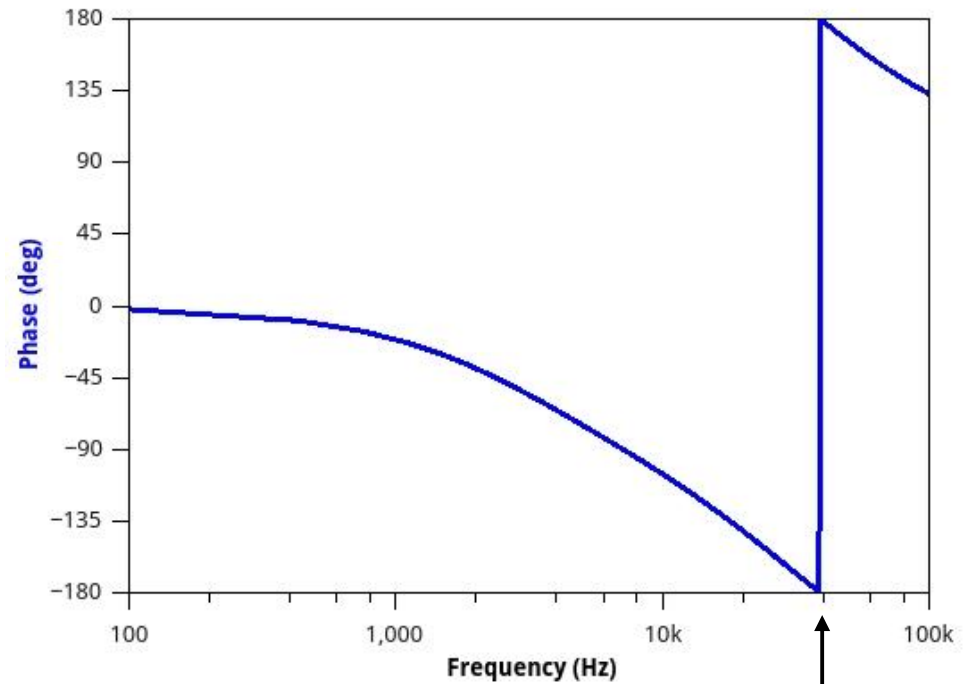
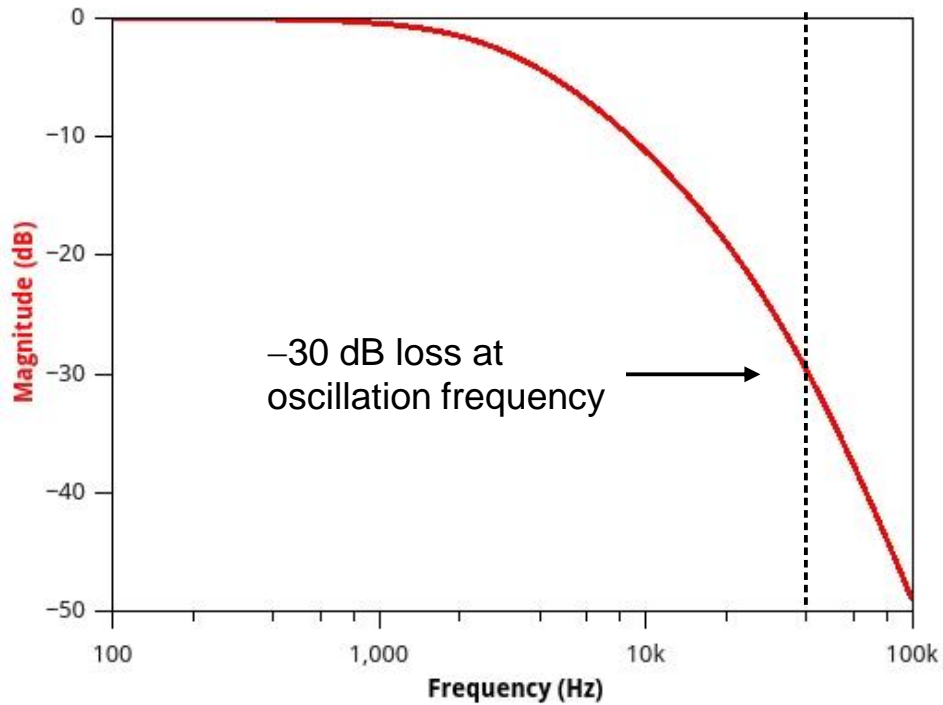


Oscillation frequency

3-Stage RC network provides adequate feedback phase-shift for oscillations

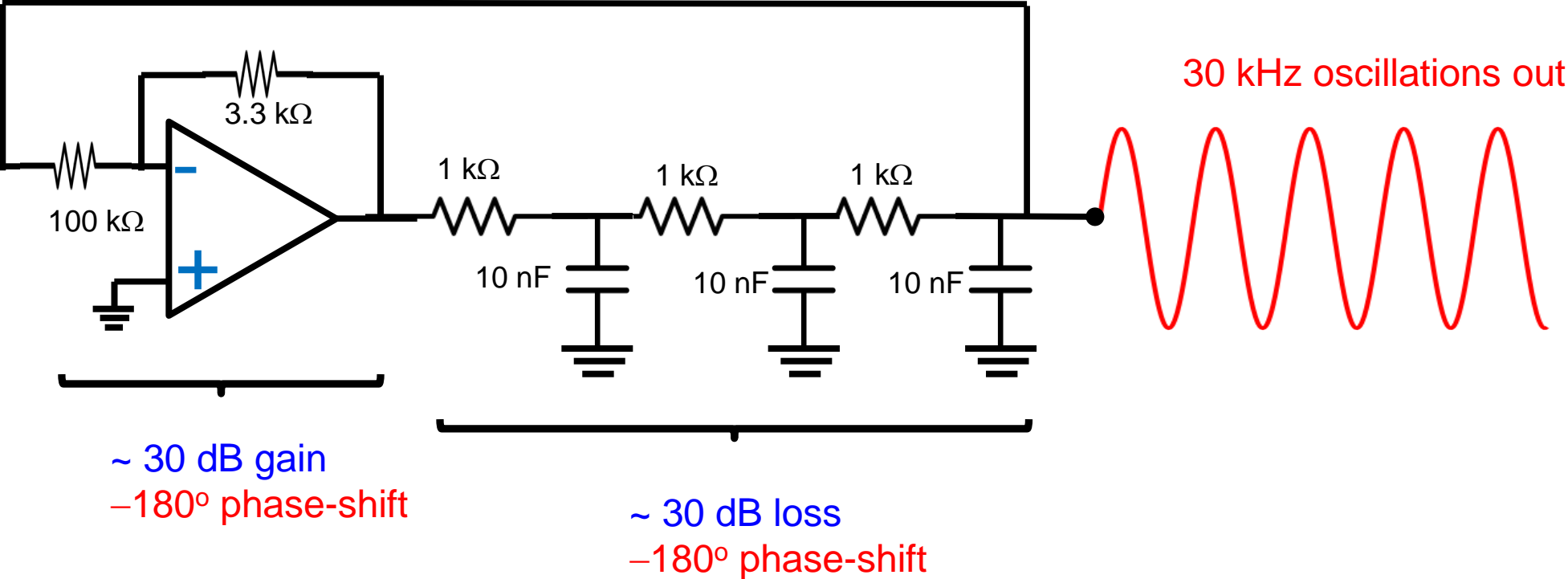


Bode plots of **Magnitude** and **Phase** for 3-stage RC low-pass filter



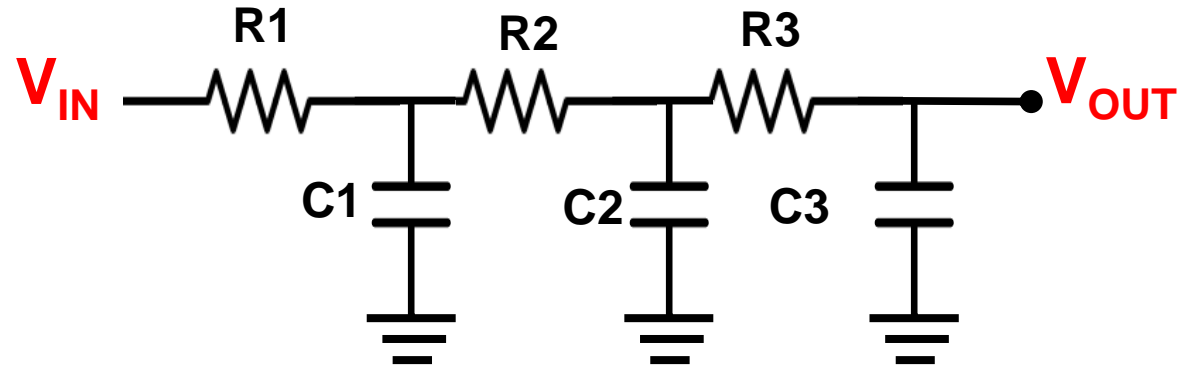
Oscillation frequency

Phase-shift oscillator



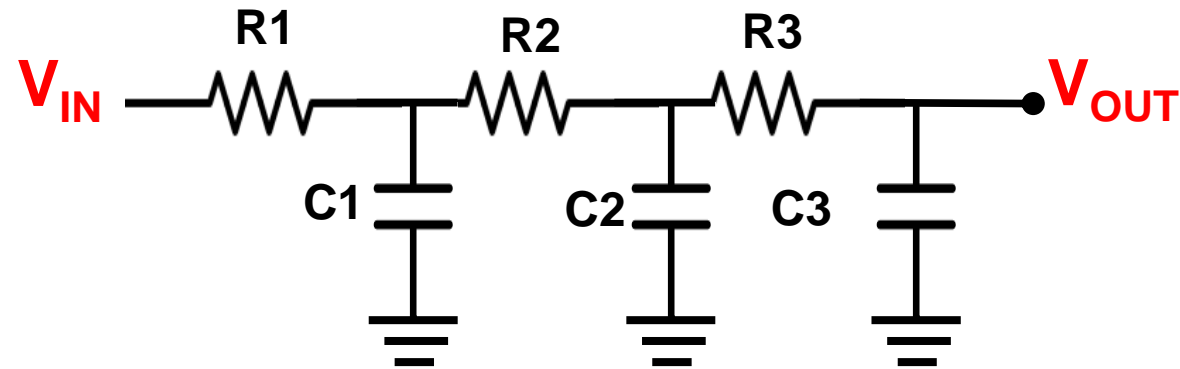
Analysis of feedback circuit is difficult because of loading

RC filters are coupled!

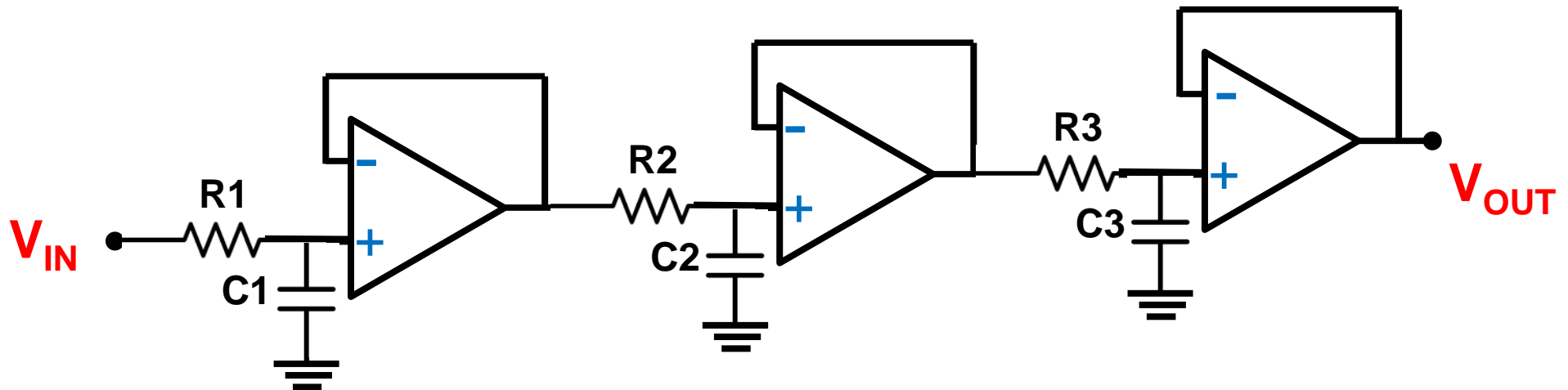


Analysis of feedback circuit is difficult because of loading

RC filters are coupled!

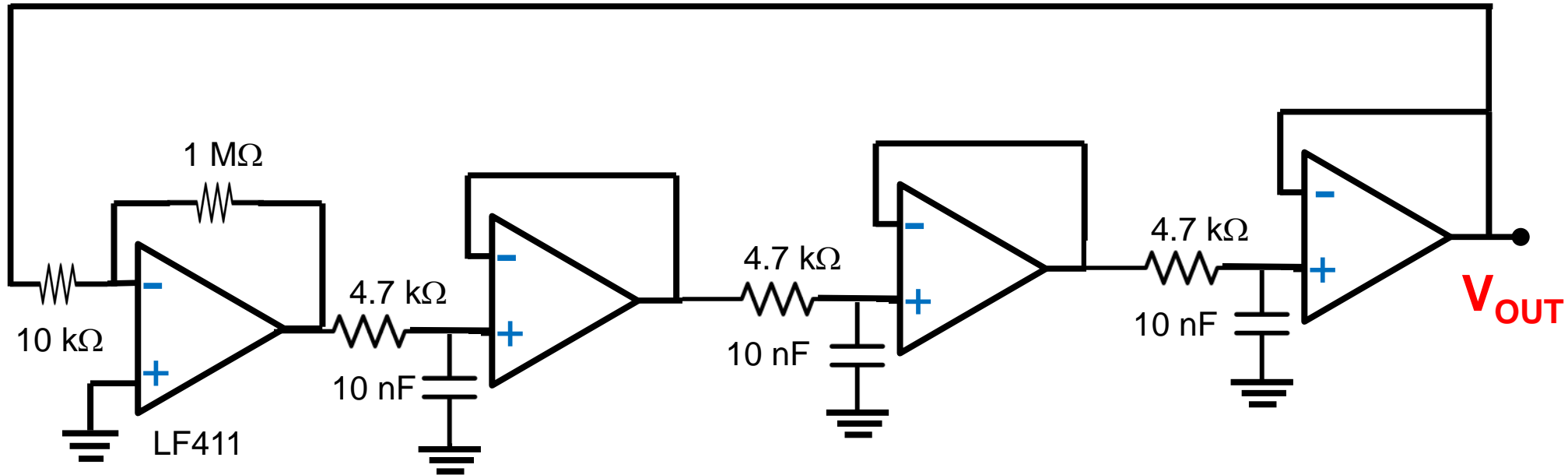


Better approach: Buffer amplifiers



$$\frac{V_{OUT}}{V_{IN}} = \left[\frac{1}{1 + j\omega R1C1} \right] \left[\frac{1}{1 + j\omega R2C2} \right] \left[\frac{1}{1 + j\omega R3C3} \right]$$

Buffered phase-shift oscillator



Phase-shift oscillator is just one of many ways to build electronic oscillators

Feedback oscillators:

Phase-shift

Wien bridge

Resonant LC (artificial atom!!!)

Negative resistance oscillators

Used in microwave electronics

Relaxation oscillators

Voltage-controlled oscillators