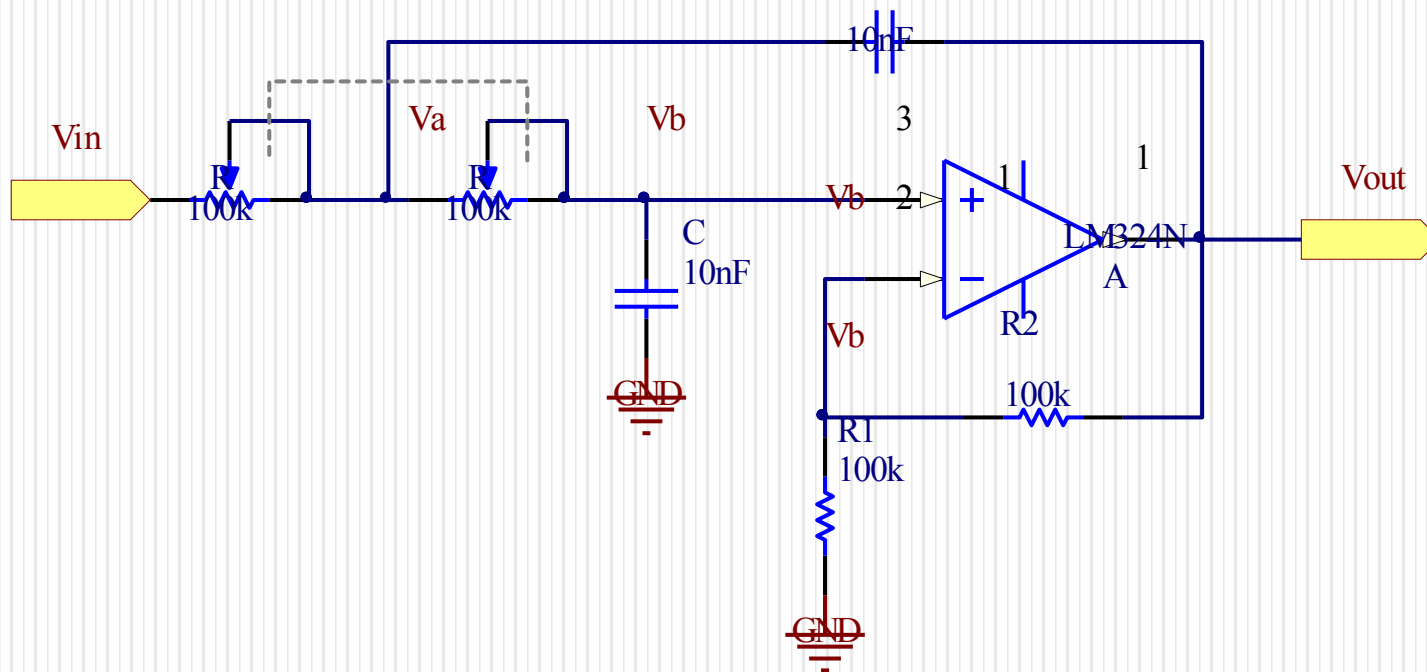


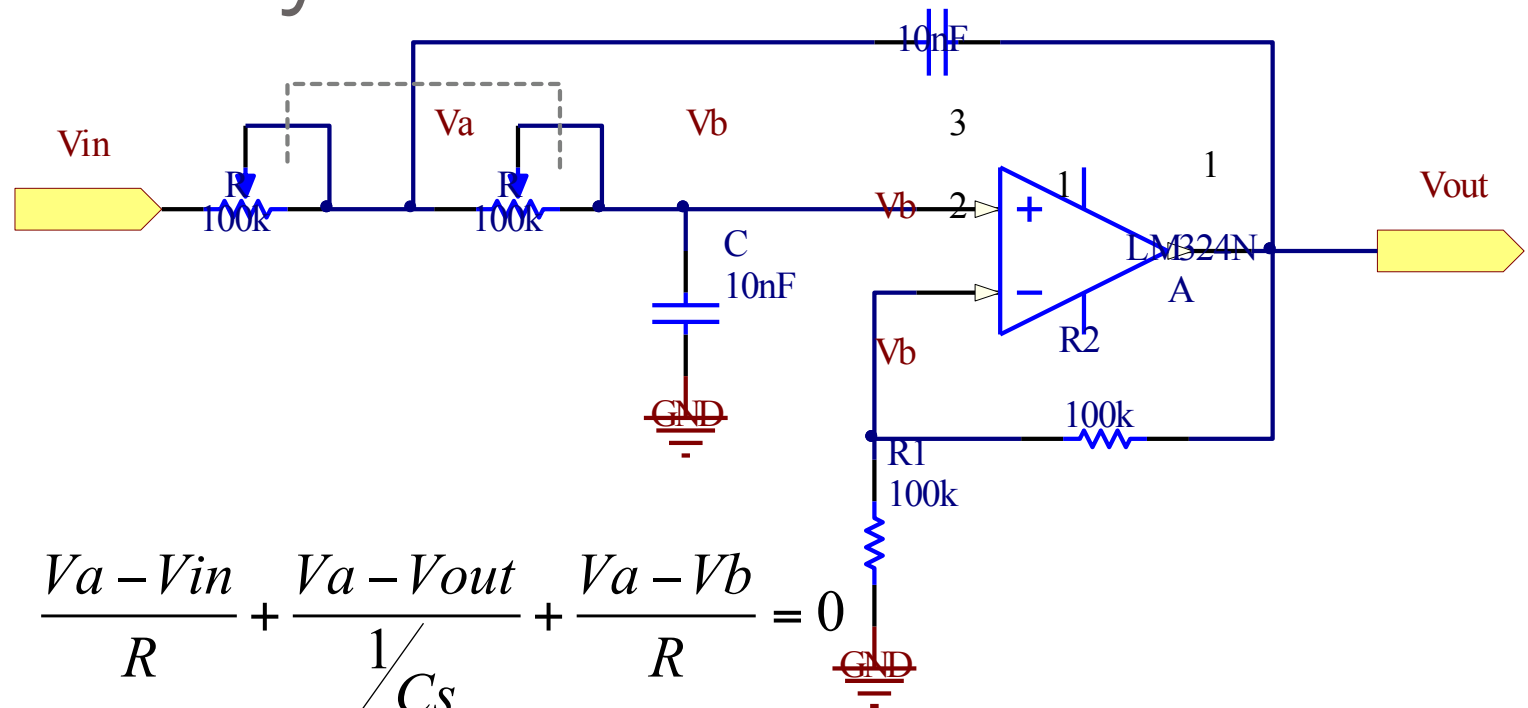
MAE 140: Linear Circuits – Winter 2013

Circuit Demonstration #4

Active Second-order Low-pass Filter



Circuit Analysis



KCL at A:
$$\frac{V_a - V_{in}}{R} + \frac{V_a - V_{out}}{1/Cs} + \frac{V_a - V_b}{R} = 0$$

Voltage division:
$$V_b = \frac{1/Cs}{R + 1/Cs} V_a = \frac{1}{1 + RCs} V_a \Rightarrow V_a = (1 + RCs)V_b$$

Voltage division:
$$V_b = \frac{R1}{R1 + R2} V_{out} = \frac{1}{K} V_{out}, \quad K = 1 + \frac{R2}{R1}$$

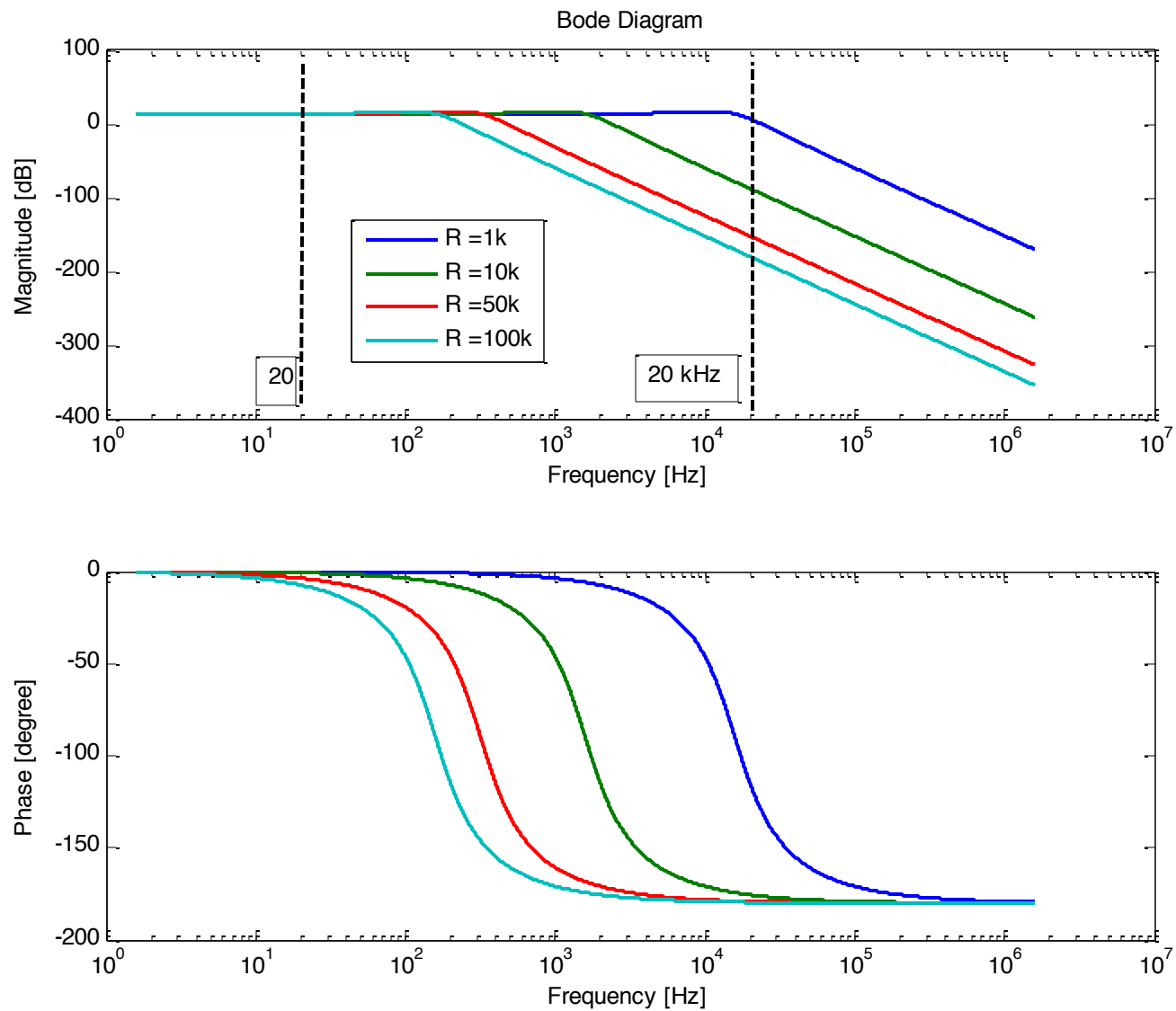
Filter Transfer Function

$$T(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{K}{R^2 C^2 s^2 + (3 - K)RCs + 1}$$

$$\lim_{s \rightarrow 0} T(s) = \text{DC gain} = K = 1 + \frac{R_2}{R_1}, \quad 1 \leq K < 3$$

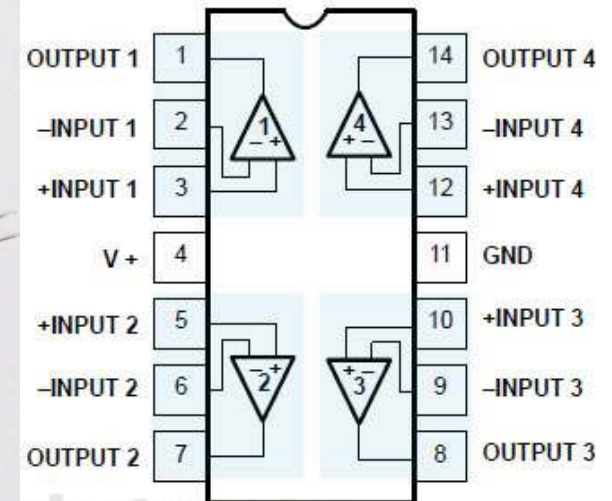
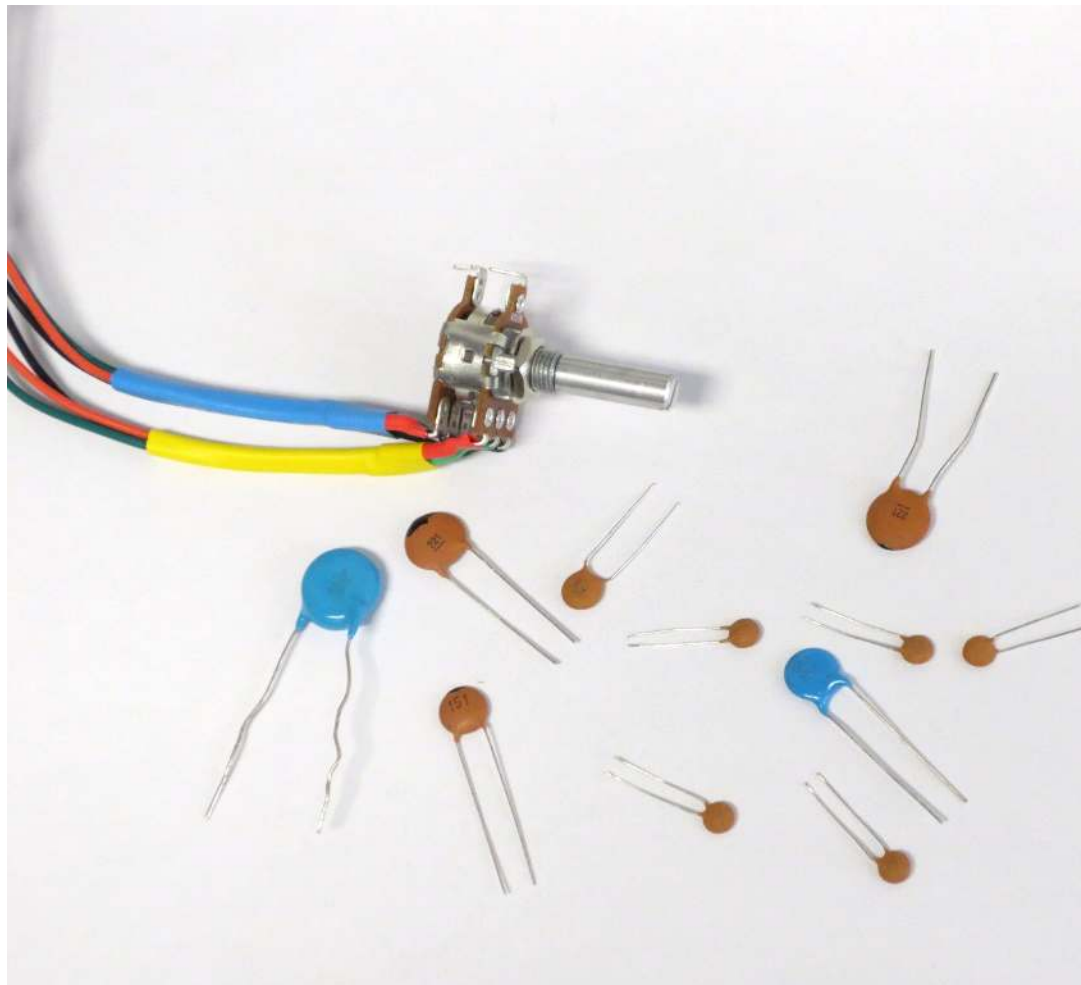
$$\lim_{s \rightarrow \infty} T(s) = 0$$

Bode Diagram



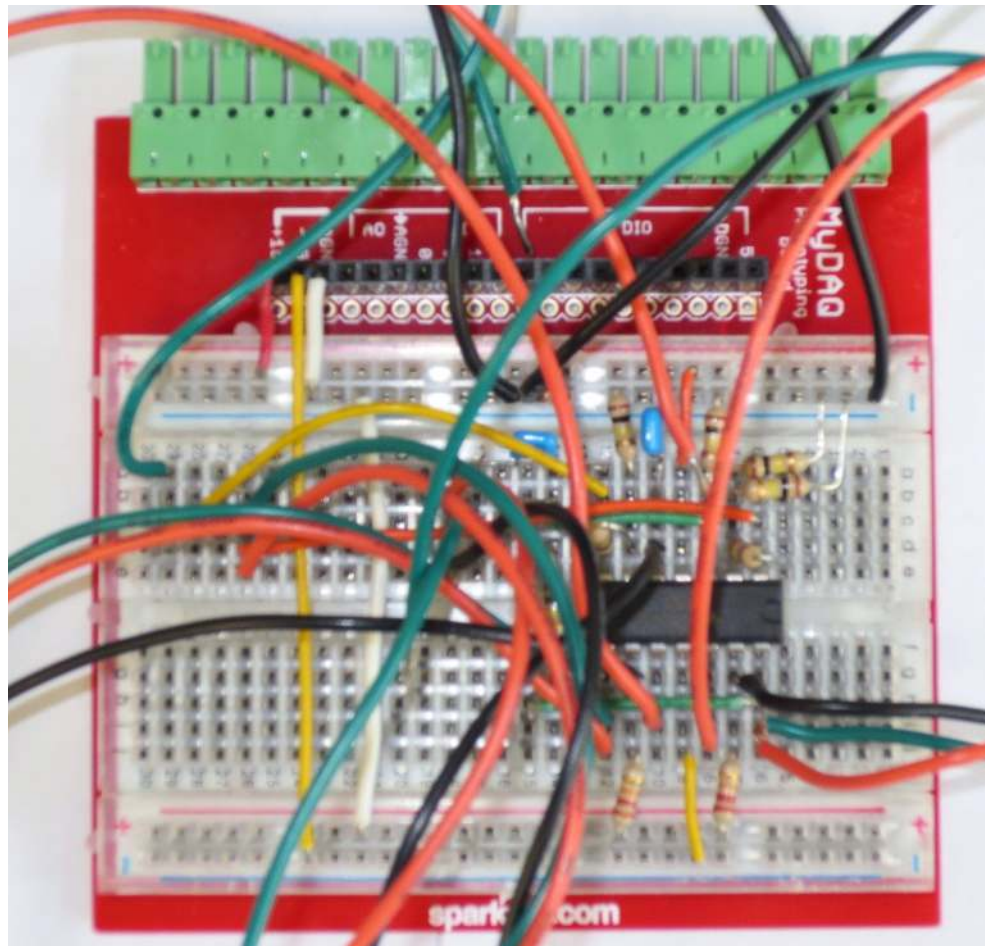
New circuit components

- LM324 OpAmp, Capacitors and dual potentiometer



Constructed Circuit

- Audio mixer + Active filter



Constructed Circuit, with connectors, and volume and cut-off frequency controllers

