Duke University
Department of Physics

Physics 271 Spring Term 2017

WUN2K FOR LECTURE 10

These are notes summarizing the main concepts you need to understand and be able to apply.

- Passive RLC filters of several types can be constructed: one can make low-pass, high-pass, band-pass and band-rejection circuits using various configurations of R, L and C. The transfer functions will have denominator $(1-\omega^2 LC) + j\omega RC$. They are characterized by two corner frequencies: $\omega_1 = \frac{1}{RC}$ and $\omega_2 = R/L$, as well as $\omega_r = \sqrt{w_1 w_2}$. The poles occur at $\hat{s} = \frac{-\omega_2 \pm \sqrt{w_2^2 - 4\omega_1\omega_2}}{2}$; the positions of the poles in the $\hat{s}$ plane can help understand the transient response of the resonant system.

- *Amplifiers* are active circuit elements that can increase voltage amplitudes; they can be treated as filters with gain, with frequency-dependent gain $\hat{A}(\hat{s})$ playing the role of $\hat{H}(\hat{s})$. A common implementation is the *operational amplifier* or "op-amp". The behavior of an amplifier can be modeled by a single-pole low-pass filter, $\hat{A}(\hat{s}) = A_0 \hat{H}_{\mathrm{low}}(\hat{s}) = \frac{A_0}{1+\hat{s}/\hat{s}_a}$, where A_0 is called the "DC" or "zero-frequency" gain, and the pole is at $-\hat{s}_a$. Several amplifiers may be cascaded to form a multipole amplifier.

- Amplifier output can in practice be very unstable, varying from device to device and with temperature, power supply voltage, etc. A very common and useful trick to stabilize amplifier output (typically at some affordable cost in gain) is to employ *negative feedback*. The idea is to "feed back" the output of the amplifier through a feedback transfer function $\hat{F}$ to the input. The resulting transfer function is $\hat{H}(\hat{s}) = \frac{\hat{A}}{1+\hat{A}\hat{F}}$. For this function, a large variation in $|\hat{A}|$ results in only a small variation in $|\hat{H}|$. For $|\hat{A}\hat{F}| >> 1$, $|H| \sim 1/|\hat{F}|$. For resistive feedback networks, we have $G = 1/F$, independent of A and quite stable.