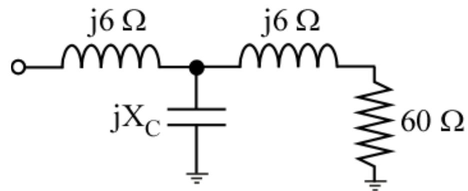
ECE 453: Wireless Communication Systems **Fall 2026**
Problem Set #5 **Due Date: 5pm, Fri, Oct 9, 2026**

1. A bandpass impedance-transforming network consists of a series inductor with reactance +j6 Ω, followed by a node at which a capacitor of reactance jX_C is shunted to ground. From the same node, a second inductor of reactance +j6 Ω is in series with a 60 Ω load.



(a) Find all values of X_C<0 that make the input impedance purely real.

(b) For each resonance solution, find the real input resistance.

(c) Which solution gives the stronger resistance transformation, and what is the approximate loaded-Q indicator $|X_{L1}|/R_{in}$ for that solution?

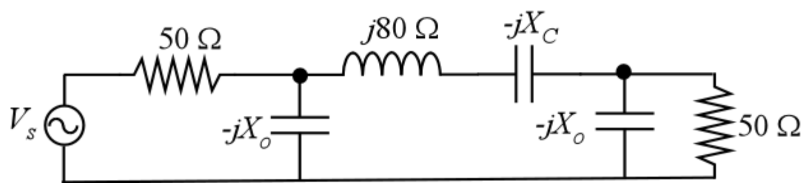
2. An ideal single-resonator LC bandpass filter is used between equal source and load resistances. Its loaded Q with lossless components is $Q_o = 8$. The inductor is then replaced by one with the same L but component Q, $Q_L = 50$ at the center frequency. Assume the capacitor is lossless.

(a) Derive the new loaded Q, Q_{new} in terms of Q_o and Q_L.

(b) Find the percentage increase in 3-dB bandwidth.

(c) Derive the center-frequency power ratio $P_{load,new}/P_{load,ideal}$ and find the insertion loss in dB.

3. A symmetric single-resonator bandpass filter is connected between 50 Ω source and load resistances. At the center frequency f_o = 60 MHz, each end of the resonator is shunted to ground by an identical capacitor having reactance X_o<0. Between the two end nodes is a series combination of one inductor and one capacitor. The inductor reactance at f_o is +80 Ω. Design the remaining reactances so that the filter is matched at f_o and has a 5.0% 3-dB fractional bandwidth.



(a) Find X_o and the series-capacitor reactance X_C at f_o.

(b) Find L, the series capacitance C_s, and each shunt capacitance C_{sh}.

(c) Verify the lower and upper 3-dB frequencies.