Diagnostic Ultrasound Imaging: Inside Out by T. L. Szabo
Prerequisites: Read Chapter 5
List of Problems

1. (a) Use Eq. (5.15a) to show that this equation for R_A at resonance reduces to Eq. (5.8a) when $Z_L = Z_R = Z_C$.
   (b) For Z_B =5 MegaRays and Z_C =29.8 MegaRayls and an appropriate matching layer for a water load, find the ratio of R_A at resonance to the value found in part a. ,
2. (a). The goal of this problem is verify, by independent calculation (a calculator or equivalent), the values produced by xdcr.m for the following variables at resonance: Real (Z_T) and Imaginary (Z_T), and AL and EL. Use Eq.'s (5.13- 5.15) and (5.22-5.27), as appropriate. Compare the calculated values to those computed by the program. Note all array values can be found from the MATLAB prompt. For example, find the resonant frequency used in the program after it has been run by typing f_0. The corresponding frequency array value is f(30), for example. Use the default parameters in the program except to set up the following two conditions: (1) no matching layer ml = 0 and no tuning L_s = 0 and (2) the default matching layer enabled ml=1 with tuning L_s=5.14 uH.
   (b) What are the improvements in dB in EL and AL for the tuned and matched case? What is the improvement, if any, in the -3 dB TL bandwidth and the effective -3 dB center frequency?
3. Given a new composite material, find out how your design compares with the matched and tuned case for PZT 5H material in problem 2 as in 2b. The specs for this crystal are coupling constant=0.80, sound speed=3.0 e3 *mls,* density =6.0e3 kg/m3 and a relative clamped dielectric constant = 376. Use a straighforward design in terms of selecting the thicknesses of the crystal and the matching layer impedance and tuning inductor. Select a center frequency of 3.0 MHz for your tuned and untuned designs (both with matching layers) and compare fractional -3 dB bandwidths (-3 dB bandwidth/center frequency) also. Which has a more significant effect on this design, AL or EL ? Plot TL, AL, and EL vs. f for both cases. Print out the variables in your program up to and including the tuning parameters.
4. Bonus problem. Can you improve significantly on your composite material design from problem 3? Try the following: run the xdcr program with no tuning or matching layer and find the frequency at which sensitivity is greatest. Scale the crystal thickness to move the minimum loss frequency to 3 MHz .Retune and add matching layer. How do the new tuned and untuned designs compare with those of Problem 3? Hints can be found in Section 5.4.6. Of the four designs which would you think is the best design for imaging? Why? Plot curves and print out the variables in your program up to and including the tuning parameters.