Homework Policy: You are allowed to work with others on homework, BUT under 2 rules:
  o Rule 1: You write your own solutions.
  o Rule 2: You list all the other students with whom you collaborated on the assignment at the top of your homework.

Odd-numbered teams are doing L4.1 first, and even-numbered teams are doing L4.2 first. This means that teams 1,3,5, etc. will solder components for the IF filter and test it, while teams 2,4,6, etc. will solder components for the RF harmonic filter and test it. Then you will swap circuits and only test the one that your complementary team built.

ODD GROUPS DO THIS PART FIRST

Notes on soldering:
- Your team will receive one board which you cannot destroy (we do not have the funds to make too many of these);
- Do not cut any of the component leads ahead of time, you can do that after they are placed in the board, soldered and/or checked by someone.
- Make sure you have the insulation removed well from components such as inductors so that the leads can be the right length when mounted in the board.
- Do not use too much solder; this can lead to short circuits that are difficult to fix.

L4.1: IF Crystal Filter

In the NorCal40A receiver, the 7MHz received RF signal is down-converted, using a mixer and a 2.1MHz oscillator, to a 4.9MHz intermediate frequency, and a 9.1 MHz sum frequency which needs to be rejected. The IF filter is a 4-element Cohn filter, shown in Figure 4.1 below.

![Figure 4.1. The IF filter in the NorCal40A is a 4-element Cohn crystal filter.](image-url)
Draw the equivalent circuit diagram using the crystal equivalent electrical circuit and explain how this works as a bandpass filter:

Explanation of how the crystal filter works as a bandpass:

Now build the filter (Fig.4-1). You will need to find 4 crystals with resonant frequencies that are within about 20Hz of each other. Use the procedure from Homework 3 to do this (page 114 in the book). Use 270-pF disk capacitors for the C9-C13 and solder them into Board 2. Slide a plastic crystal spacer onto the leads of each of the four crystals, all the way against the metal case. Install the crystals X1 through X4 close to the board. The metal cases are not connected to the leads, so they are not connected to any part of the board, and we say the case is floating. This is not a good idea because it can lead to ground loops, so we will connect all of the cases through a small hole in the middle of the board with some wires.
The filter is designed for a 200-Ω generator and load, so you need to add a 200-Ω resistor in parallel with the scope input, using as short of a cable as possible (why?). You also need a 150-Ω resistor in series with the function generator. Set the amplitude to 0.5Vpp and measure the minimum loss of the filter.

\[ L_{\text{min}} = \text{_______} = \text{_______} \text{ dB} \quad \left[ L = 20 \log \left( \frac{V_m}{V} \right) \text{ dB} \right] \]

Plot the filter loss in dB as a function of frequency by changing the function generator frequency. Increase the function generator output to 2V and measure the output voltage over a 2500Hz bandwidth centered on the pass band. Often 50Hz is a good increment in the pass band, and 100Hz is good in the stop band, but use your judgment if this does not work for you.

What is the upper sideband rejection? \( r_{\text{upper}} = \text{___________} \text{ dB at } f_U = \text{__________} \)

Label the rejection and the upper sideband rejection on your plot.

What is the 3-dB bandwidth of your filter? \( BW = \text{__________________} \)
When you are done testing the crystal filter, give it to your partner group and measure the RF harmonic filter that they made.
EVEN GROUPS DO THIS PART FIRST

Notes on soldering:
- Your team will receive one board which you cannot destroy (we do not have the funds to make too many of these);
- Do not cut any of the component leads ahead of time, you can do that after they are placed in the board, soldered and/or checked by someone.
- Make sure you have the insulation removed well from components such as inductors so that the leads can be the right length when mounted in the board.
- Do not use too much solder; this can lead to short circuits that are difficult to fix.

L4.2: RF harmonic filter

In the NorCal40A, the harmonic filter is connected to the antenna. This is the circuit you analyzed in Spice. In the block diagram of the radio, the capacitors are $C_{45} = 330 \text{pF}$, $C_{46} = 820 \text{pF}$ and $C_{47} = 330 \text{pF}$. The numbers in parentheses are the numbers indicated on the printed circuit board you will use later. The inductors $L_7 = L_8$ for a cutoff frequency of 7MHz will be roughly those of 18 windings on a T37-2 core with the inductance constant of $A_L = 4 \text{nH/turn}^2$.

Wind 2 inductors and measure their inductance using the inductance meter to check the values. Solder the components in Board 1.
Measured inductor values:

L1 = _________________                     L2 = _________________

Did you need to fix the inductors to get the values closer? _________________

Connect the filter to the generator and a scope and measure the loss response, defined as

\[ L = 20 \log \left( \frac{V_m}{V} \right) \text{ dB} \]

What is the loss at 7MHz? \( L(7\text{MHz}) = \) _________________

What is the value of the ripple in the pass-band? _________________

What is the loss at 14MHz, 21MHz and 28MHz?

\[ L(14\text{MHz}) = \] _________________ \( L(21\text{MHz}) = \) _________________ \( L(28\text{MHz}) = \) _________________