On Site Homework #4

ECEN 2420: Wireless Electronics for Communication

Goals

- Build and measure the NorCal 40A 4.915 MHz Crystal IF Filter
- Build the receiver mixer

Problems

Problem 1

Make sure that your oscilloscope probe is set to 10:1 attenuation to avoid getting wrong results that result from the capacitance of the coaxial cable and the input resistance of the oscilloscope.

The schematic of the crystal filter is shown below. You can also check the assembly manual for a complete schematic.

Here are the parts used for the Crystal IF Filter
On Site Homework #4

And a table for the individual parts

<table>
<thead>
<tr>
<th>Picture</th>
<th>Reference</th>
<th>Description</th>
<th>Part Number</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="C9...C13" /></td>
<td>C9...C13</td>
<td>Cap. Disc, 270 pF, 5%</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="C14" /></td>
<td>C14</td>
<td>Cap. Disc, 47 pF, 5%</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="L4" /></td>
<td>L4</td>
<td>Ind., Choke, 18 uH</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
On Site Homework #4

<table>
<thead>
<tr>
<th>X1...X4</th>
<th>Crystal, 4.915 MHz, HC-49</th>
<th>Matched to +/-20 Hz</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misc</td>
<td>Spacer, Plastic, HC-49 Crystal</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

We will now build the filter on the board.

**Do NOT solder the inductor L4 or capacitor C14 yet!**

As a reminder, soldering tips are presented here again.

Some general tips for soldering

1. The components mount on the side of the PCB with the white lettering. The solder is applied to the other side of the board.
2. Insert the part you want to solder. Bend the leads a little so the part does not fall out. The parts should be soldered close to the board.
3. Keep the sponge of the soldering station wet and wipe the tip of the soldering iron frequently enough to keep it clean and keep the solder coating the whole tip.
4. Apply the tip and solder at the same time to the PCB and the lead of the part to be soldered. Avoid applying excessive heat and do not use more solder than needed to make the joint.
5. Clip off the wire ends close to the PCB
6. Inspect the solder joint. The solder should coat the wire completely and cover the hole in the PCB.

We will start soldering with the plastic crystals. Place a plastic spacer onto the bottom of each plastic crystal as shown below.
Solder these crystals with spacers onto the board.

The metal cases are not connected to leads or any part of the circuit yet – thus the cases are electrically floating. It is generally a bad idea to leave large pieces of metal in a circuit floating, because circuit signals can capacitively couple through the metal pieces, and interfere with the entire system. To avoid this, we connect each case to ground. In the middle of the 4 crystals there is a hole that is connected to ground. Solder a blank piece of wire into the hole and let it extend above the top of the crystals on the component side. Use additional pieces of wire to solder the metal cans of the crystals together. Then connect the ground wire to the wire that interconnects the crystal cans. The picture below shows one way of doing this.
On Site Homework #4

Next, solder in the 5 270 pF disc capacitors.

**Again, do NOT solder L4 and C14.**

The crystal filter, completed for this problem, is shown below.

The crystal is designed for source and load resistances of 200 ohms. To measure the filter, we need to use a 150 ohm resistor on the input side (C9) and a 200 ohm resistor to ground on the output side (C13). Use either resistors that you have, or else obtain these resistors from the TA station. Solder these resistors to the underside of the board as shown below.

Attach the waveform generator output and the oscilloscope probe as shown in the next figure.
Q1) Why do we connect 200 Ω resistor to the load and a 150 Ω resistor at the input?

Measure the filter

Q2) Make a plot of dB vs. frequency of the filter response. Use your own judgment when choosing the frequency intervals. Make sure to have a picture of this graph for the paper you turn in. (Hint: $L = 20 \log \left( \frac{V_L}{V} \right)$).

Q3) What is the 3 dB beamwidth of the filter?

Q4) What is the minimum loss of the filter?

Q5) What is the out of band rejection of the filter? (The filter receives both a ~4.91 and ~9.1 MHz signals)

When you have finished this, remove the two resistors from the underside of your board.

Problem 2

The goal of this problem is to build the receiver mixer of the NorCal receiver and complete the termination of the IF filter (L4 and C14). Once this is done, an RF signal can be injected at the mixer input and, by tuning the VFO, the signal should appear, selectively filtered at the IF filter output. In addition to the desired RF signal there is also a second RF signal at the image frequency that can make its way through the mixer and the IF filter.
On Site Homework #4

The schematic of the receiver mixer is shown below

The parts needed to build this mixer are shown below
### On Site Homework #4

A list of the individual parts is given below

<table>
<thead>
<tr>
<th>Picture</th>
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<th>Part Number</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="C4" /></td>
<td>C4</td>
<td>Cap. Disc, 4.7 pF, 10%</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><img src="image2" alt="C5" /></td>
<td>C5</td>
<td>Cap. Disc, 0.01 uF, 20%, 25 V</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><img src="image3" alt="C6" /></td>
<td>C6</td>
<td>Cap. Disc, 47 pF, 5%</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><img src="image4" alt="C8" /></td>
<td>C8</td>
<td>Cap. Disc or Mono, 0.047 uF, 20%, 25 V</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><img src="image5" alt="T3" /></td>
<td>T3</td>
<td>Transformer, Pri: 23T, #28 (16&quot;), Sec: 6T, #26 (6&quot;), 3.83:1</td>
<td>FT37-61 (black, 0.37&quot;=9.4mm), Ferrite Toroid, AL = 55 mH/1000T</td>
<td>1</td>
</tr>
<tr>
<td><img src="image6" alt="U1" /></td>
<td>U1</td>
<td>IC, Mixer/Oscillator</td>
<td>SA602AN</td>
<td>1</td>
</tr>
</tbody>
</table>

Solder the receiver mixer of the NorCAI 40A board as shown below. You may also solder L4 and C14 to the board (L4 and C14 are an impedance transformer at the output of the Crystal IF filter). **Make sure you solder the right part to the right location.**
On Site Homework #4

This mixer will be measured in a future on site homework.