Yukon Amateur Radio Association
Pixie Workshop, Lesson 2 -
The Power Amplifier/Mixer and Low Pass Filter

In today's lesson you will install R2, R5, L1, L2, L3, C2, C5, C6, C9, and Q2. You will start with the low pass filter components C5, L2 and C6 and do some test on this section of the circuit before other parts are attached to it.

As you saw in Lesson 1, the oscillator produces a fundamental frequency at about 7.023 MHz and harmonics at whole number multiples of the fundamental frequency. If they are not attenuated these harmonics cause interference on the frequencies at which they appear. It is the function of the low pass filter to reduce the strength of the harmonics to levels at which they should no longer cause a problem.

The low pass filter in the Pixie is a "three pole filter", that is, it has three active components, two capacitors and one inductor. Draw the low pass circuit in the space below.

Note that the capacitors in this filter provide a path by which RF can travel to ground and the inductor is in series, inhibiting the flow of RF. As the frequency goes up, the capacitors provide an easier and easier ground path whereas the inductor is increasingly inhibitive. Consequently, as the frequency increases the output from the filter should decrease in amplitude.

Let's see if this is the case.

Low Pass Filter Construction:

1. Install C5, a 470 pF capacitor marked 471. The orientation of the capacitor does not matter.

2. Install C6, another 470 pF capacitor.

3. Insert L2 into the holes for this component. Solder it in place but leave the leads long (about 1 to 2 cm) for the attachment of test equipment.

4. The low pass filter is designed to work into a load of 50 ohms impedance. Temporarily solder a 51 ohm resistor between the point where the two capacitor leads are soldered close together on the circuit board and one end of the inductor, L2. It really doesn't matter which end of L2 you choose (since the low pass filter is symmetrical) but what will later be the output end is closest to the hole in the corner of the circuit board.

Low Pass Filter Tests:

1. Connect one channel of an oscilloscope to the input end of the filter. Connect the second channel to the output end, i.e. the end with the 51 ohm resistor attached. Connect an RF generator to the input of the filter.

2. Connect an RF generator to the input of the filter.

3. Slowly vary the frequency of the signal generator over the range from say, 3 MHz to 20 MHz. On this signal generator you will have to change scales from D to E to cover this range.

The oscilloscope you are using has some limitations, principally with regard to its "bandwidth". It has a 10 MHz bandwidth, which means that as the frequency goes above 10 MHz the oscilloscope's sensitivity decreases rapidly. Nevertheless, because both channels are affected by this decrease in sensitivity, you can effectively compare the magnitude of the input to that of the output over the frequency range. How does the magnitude of the input compare to that of the output as you increase the frequency? Is this what you would expect for a low pass filter whose "cut-off frequency" is about 8 or 9 MHz?

4. With the RF generator and oscilloscope still connected snip the lead of the 51 ohm resistor. What happens to the input and output waveforms as you connect and disconnect the resistor? Does the frequency make a difference? Can you see one reason why it is important to match the output of a transmitter to a 50 ohm resistive load?

An instrument called a spectrum analyser can scan a range of frequencies and show the results on a screen. A spectrum analyser scan from zero MHz to about 50 MHz is shown in the figure below. The horizontal scale is 5 MHz per division and the vertical scale is 10 dB/division. The bright line is located at about 7.5 MHz. From the figure you can see how the strength of the scanning signal has decreased by about 20 dB at maximum. At 14 MHz the output is only down by about 6 dB (a decrease in power of 1/4). This is not a very good low pass filter! Before using this radio on the air it would be a good idea to improve the low pass filter.

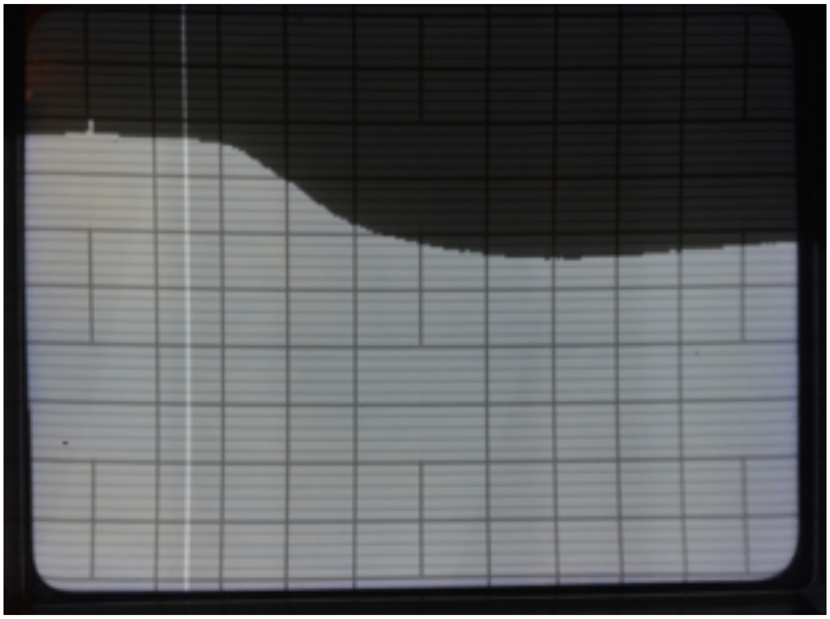

Figure 3. A spectrum analyser scan of the Pixie low pass filter from 0 to 50 MHz. Horizontal scale: 5 MHz/division, vertical scale: 10 dB/division.

Power Amplifier:

1. Install R2, a 33k ohm resistor.

2. Install L3, a 100 µH inductor. This inductor looks like a large resistor and it uses the same colour code, but is much easier to identify. The code you are looking for is brown, black, brown, followed by a silver band that indicates +/- 10 % tolerance. It does not matter which way the inductor is inserted.

3. Insert C9 ((473) into its spot on the circuit board. Solder the leads and trim the lead closest to the edge of the board. Leave the other lead long.

4. Install R5, a 10 k ohm resistor.

5. Insert transistor Q2 into its position on the circuit board. This transistor is marked 8050. As for Q1, it matters which way it goes - the shape of the transistor should match the outline on the circuit board. Solder Q2 in place and trim the outer two leads, leaving the centre lead long.

6. Install C2 (103).

7. Insert L1 (red, red, black, silver) into its position on the board. Solder the inductor in place and trim the lead closest to the edge of the board but leave the other lead long.

Power Amplifier Tests:

1. Resolder the 51 ohm resistor across the output of the low pass filter and connect the oscilloscope across the resistor. Apply power to the circuit board. You should see a signal on the oscilloscope. Estimate the peak to peak voltage.

Peak to peak voltage = ____________V

2. Connect a short jumper wire from the ground connection of D1 to the long lead of C9. If you see a big jump in the amplitude of the signal on the oscilloscope, CONGRATULATIONS, your power amplifier is working! Estimate the peak to peak voltage but don't leave the jumper wire connected for too long or Q2 will overheat.

Peak to peak voltage = ____________V

3. With the first channel of the oscilloscope still connected to the 51 ohm resistor, connect the second channel of the oscilloscope to the long lead of L1. Attach the jumper to the long lead of C9. Compare the two waveforms.

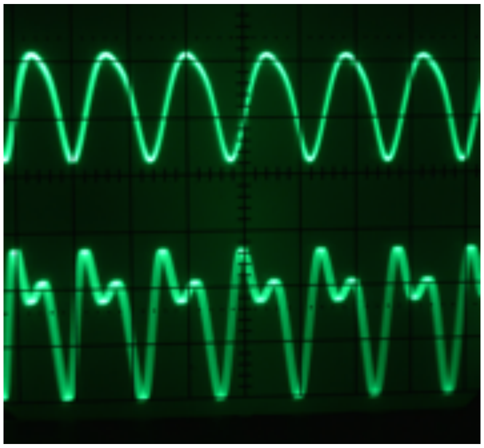

Figure 4. Power amplifier output with 51 ohm load. Top trace = output, bottom trace = collector of Q2. Note the effect of the low pass filter.

4. With the oscilloscope and jumper connected, snip the lead to the 51 ohm resistor. What happens to the output waveform?

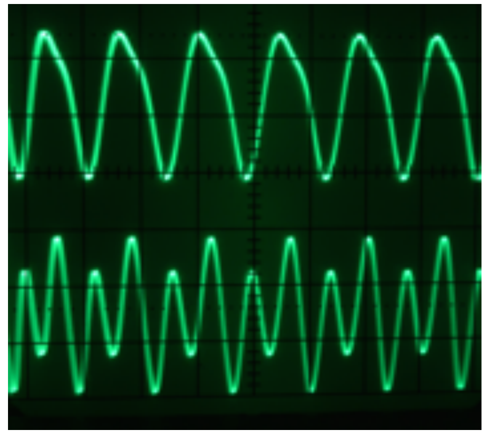

Figure 5. Power amplifier output with no load. Top trace = output, bottom trace = collector of Q2.

Mixer Tests:

1. Attach one probe of the oscilloscope to the lead of C9. Set the oscilloscope to 10 mV/division on the vertical scale and 2 ms/division on the horizontal scale.

2. Resolder the 51 ohm resistor across the output of the low pass filter. Then connect a lead from the RF generator to an attenuator and another lead from the attenuator to the 51 ohm resistor.

3. Apply power to the circuit board and adjust the RF generator so as to sweep the frequency around 7.023 MHz. As you sweep the frequency what do you see on the oscilloscope? You should be able to find two RF frequencies that produce an audio frequency of about 1 kHz.