18-MHz crystal oscillator

In this task, you build a 18-MHz crystal oscillator, a.k.a. a Pierce oscillator. The oscillator is based on the common-emitter amplifier that is familiar from a previous exercise. The Pierce oscillator uses a crystal and two capacitors, Fig. 1. Fig. 2 shows an equivalent circuit of a crystal which incorporates an inductor and a capacitor in series, as the LC-oscillator tested before.

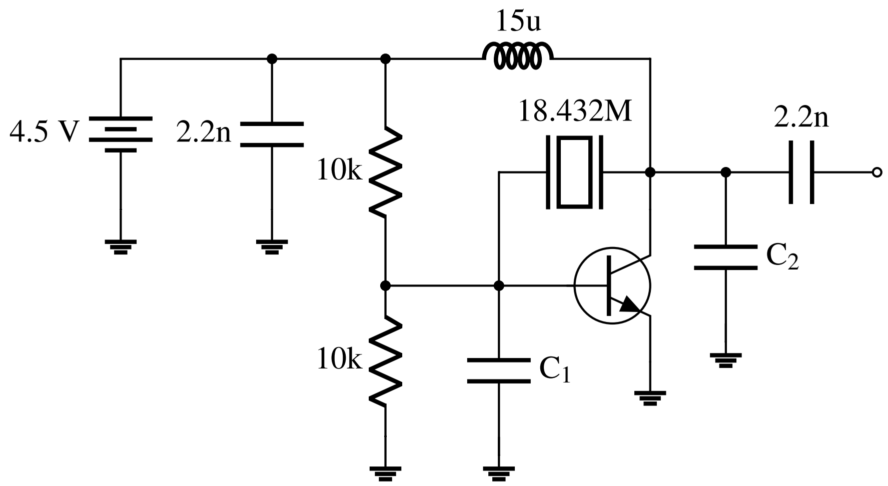

Figure 1: Crystal replacement. You can test this with either $C_1 = C_2 = 33$ pF or $C_1 = C_2 = 330$ pF.

Testing DC operation

- Connect 4.5 V from the Virtual Bench (VB) DC power power supply.
- Disconnect the feedback LC loop in order to disable oscillation, before you attempt to check the DC operation. (The DC readings are probably different when the circuit oscillates.)
- Check with the VB multimeter that the transistor gets biased properly: read the DC current consumption from the DC power supply. The DC operation should be OK if the current consumption is about 20 mA.
- Just to make sure, measure the emitter-to-base voltage is about $V_{be} \approx 0.7$ V.

Testing RF output

- Connect the feedback LC loop again.
- Monitor the RF signal at the RF output (v_{out}) with the Virtual Bench oscilloscope. Set the oscilloscope **probe to 10x**. Use a time scale on the horizontal axis such that you are able to see a sine wave with several periods. The period length is $\tau = 1/(18.4\text{MHz}) = 54$ ns. For the vertical scale, you might use something like 500 mV/div.
- You should see a signal whose period is near 50 ns. Record the amplitude. The amplitude should be several volts, peak to peak.
- If the output signal is OK, go to the course instructors for testing the output in a spectrum analyzer. The spectrum analyzer can be used to check the frequency stability and drift.
- Is the signal anyhow better or worse when compared to the Clapp oscillator?

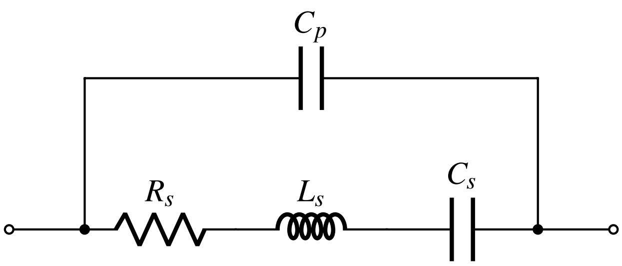

Figure 2: An equivalent circuit of a crystal incorporates an inductor and a capacitor, in series. These elements enable us to replace a real LC circuit with a crystal. The resistor models losses and the shunt capacitor the parasitic capacitance associated with the crystal metal plating and packaging. Typical orders of magnitude: L_s ten millihenries, C_s ten femtofarads, C_p a few picofarads, R_s tens of ohms.

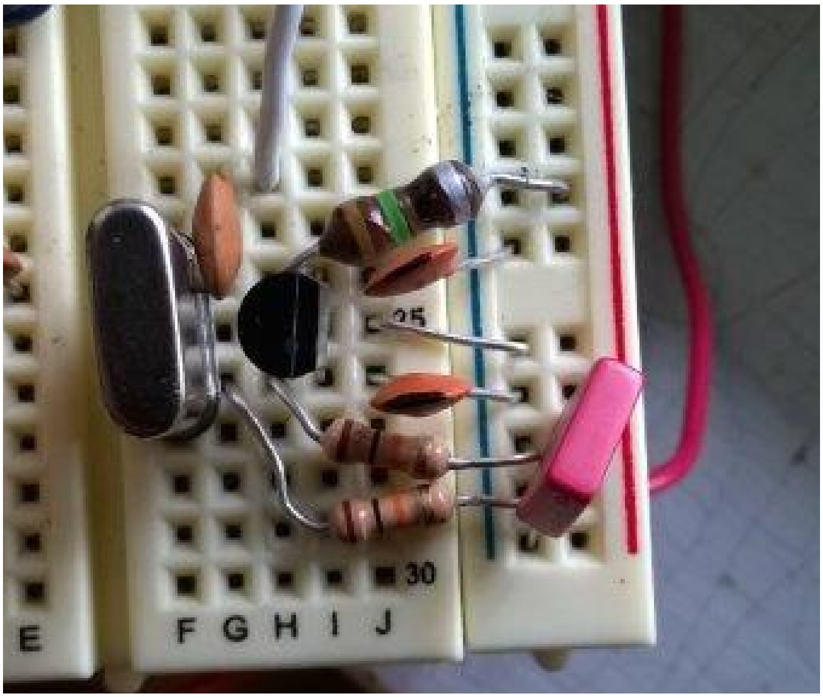

Figure 3: The crystal oscillator.

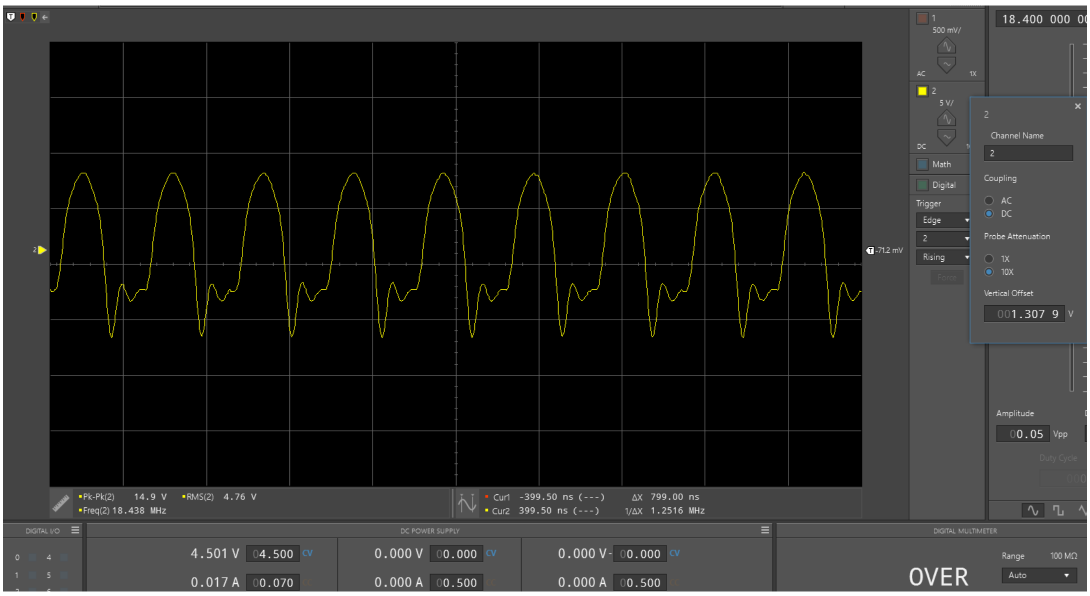

Figure 4: Output waveform from the crystal oscillator.