Development of Colpitts Self Oscillator

for Measurement of Magnetic and Superconducting Properties

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Objective: To develop and implement a precision magnetic measurement technique in a low-temperature instrument to measure temperature magnetic and superconducting materials; specifically, to develop a self-oscillator known as the Colpitts oscillator for the above purposes.

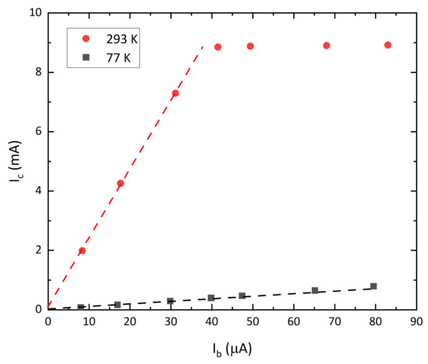
Procedure: Various tests were conducted on the circuitry at room temperature to modify the circuit as needed for its low-temperature application, and the superconductor, YBCO, was chosen as a specimen to test the performance of the self-oscillator.

The tests were conducted as follows:

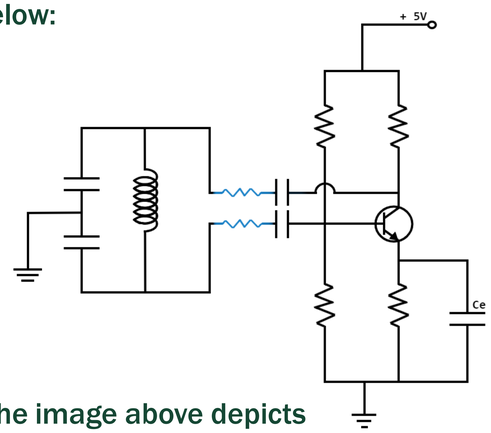
1. Characterizing the transistor at room temperature versus at the temperature the sample would be cooled to in order to determine whether the transistor would need to be inside or outside of the cryostat;
2. Testing the resistance the Colpitts oscillator could support and still function;
3. Checking the signal quality of the oscillator with different circuit components to determine the best set-up; and
4. Measuring the magnetic susceptibility of the sample YBCO, to test the performance of the Colpitts self-oscillator that was built.

Results:

1. The characterization of the transistor at room and the cooled temperature:

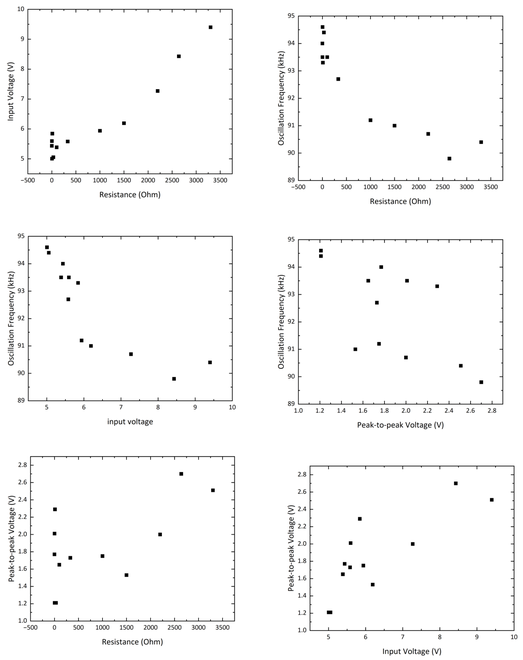


2. Based on the graph above, it was determined that the transistor would need to stay at the same temperature during the experiment, so the resistance the circuit could support was tested in the areas highlighted in blue below:



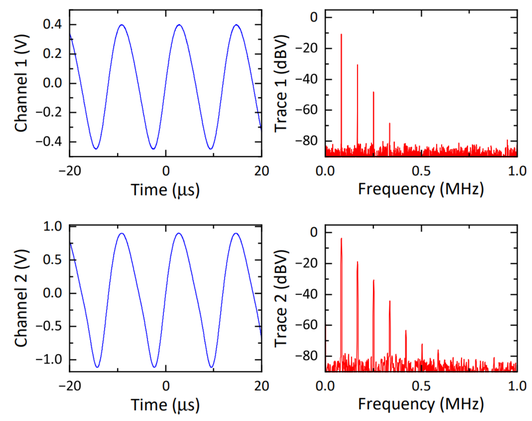
(The image above depicts the circuitry of the Colpitts self oscillator used in this experiment, with the tested resistors highlighted in blue.

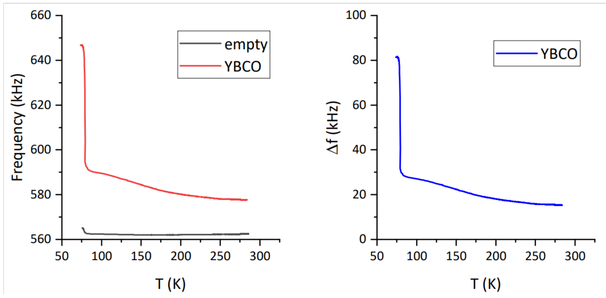
2. (Cont.) The results of the resistance tests were as follows:



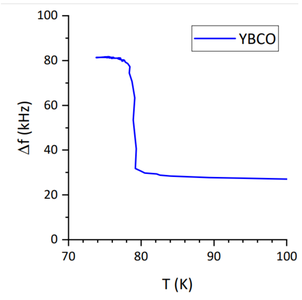
The maximum resistance the circuit could support was determined to be around 3500 Ohms, which is where the graph cuts off.

3. The signal quality of different circuit components were tested below:





4. The magnetic susceptibility of the YBCO sample was found to be as follows:



Conclusion: Based on the results, it can be concluded that the self-oscillator developed in this project successfully detected the superconducting transition of YBCO, as can be noted by the sudden jump as the sample goes from paramagnetic to strongly diamagnetic, once cooled past its Tc (critical temperature).

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