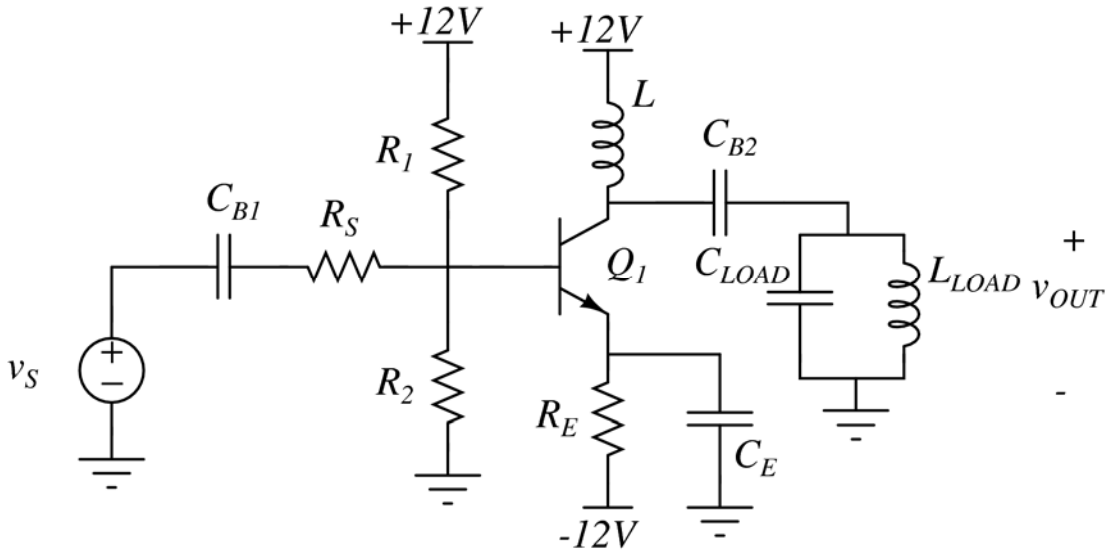
University of North Carolina, Charlotte
Department of Electrical and Computer Engineering
ECGR 3157 EE Design II Fall 2009

Lab 1
Power Amplifier Circuits

Issued August 25, 2009 Due: September 14, 2009

Exercise 4: A Power Amplifier for Radio Frequencies (RF)

Now, we are going to build the following circuit, which is a radio transmitter that is very similar to the one found in many cell phones. In this exercise, you're going to build the basic amplifier shown below.



You are given the following information:

- $R_E \approx$ 30Ohm (Power Resistor – Get this from a TA)
- $C_E \approx$ 0.82 µF or 1µF
- $C_{B1} \approx$ 0.82 µF or 1µF
- $C_{B2} \approx$ 0.82 µF or 1µF
- L ≈ 100 µH (**You will wind this).**
- $L_{LOAD} \approx$ 6.8 µH (**Get this from a TA)**
- $R_S = 0$

You will choose values for the other components below.

Please answer or do the following:

1. The transistor in this amplifier acts as a current source that draws both a DC current and an RF current. Let's quickly analyze how the circuit works. The base of the transistor is

provided with both an AC input voltage and a DC input voltage. The DC input voltage is provided by the resistors R_1 and R_2. Let's determine the DC voltage at the base with respect to ground. To do so, answer the following:

a. Does any DC current flow through the capacitor C_{B1}?
b. Assuming that a negligible amount of DC current flows into the base of the transistor, choose values for R_1 and R_2 so that the DC voltage at the base is approximately 6Volts. The total value of $R_1 + R_2$ should be at least 100kOhm.

2. As we said in class, the current flowing into the collector of the transistor is approximately the same as the current flowing out of the emitter. How much of the DC current flowing through the resistor R_E flows through the inductor L? How much flows to the output through C_{B2}? Consider the impedance of the capacitor and the inductor at DC.
3. In the lab, the voltage v_S is going to be an approximately 650kHz-700kHz sine wave. We'll call this the RF input. This signal will create a collector current at the same frequency. This current can flow through either the inductor L or the capacitor C_{B2}. One of these two components will carry almost all of the RF collector current. Determine which it is. Consider the impedance of the inductor and the capacitor at high frequencies (i.e. 650kHz).
4. The RF current flows into the load consisting of the parallel combination of C_{LOAD} and L_{LOAD}. In terms of the variables C_{LOAD} and L_{LOAD}, determine an expression for the parallel impedance of C_{LOAD} and L_{LOAD}. What happens to this impedance at the frequency

$$f_{Load} = \frac{1}{2\pi\sqrt{L_{LOAD}C_{LOAD}}} ?$$

If the frequency of the RF current is approximately the same as f_{Load}, your answer should show that the output voltage will be very large. Why is this parallel LC circuit useful in a transmitter?

5. The inductor L will be wound on the iron-powder core that was given to you. Choose an appropriate number of turns using the formula given in class. The reluctance of the core is approximately $10.1 \times 10^6\ H^{-1}$. Wind the inductor using the magnet wire that you were given. Note that the wire is covered with an insulating layer of shellac. You will need to remove some of the insulation at each end of the coil so that you can insert the inductor into your circuit. You will need to use sandpaper to remove the insulation.
6. Now, build the amplifier using a TIP31 transistor **with a heatsink**. Use the values for $R_1$and R_2 that you chose previously and use the component values listed above. Compute a value for C_{LOAD} using the relationship

$$f_{Load} = \frac{1}{2\pi\sqrt{L_{LOAD}C_{LOAD}}}$$

When calculating, let f_{LOAD} be approximately 670kHz and let L_{LOAD} be 6.8μH. Add this capacitor to the circuit.

7. Connect the function generator to the base of the transistor through the capacitor C_{B1}. Use the following settings:
   - Amplitude: 1 peak-to-peak
   - Type: Sine
   - Frequency: 650kHz
   - Offset: 0V

Now, measure the voltage across L_{LOAD} and C_{LOAD}. Carefully adjust the frequency of the input voltage until it is maximized. Using the impedance that you found in Question 4, explain why the amplitude of the output voltage behaves as it does. What type of filter is this? At this point you are ready for your check-off.