EXPERIMENT #2
CARRIER OSCILLATOR

INTRODUCTION:

The oscillator is usually the first stage of any transmitter. Its job is to create a radio-frequency carrier that can be amplified and modulated before being sent to the transmitting antenna.

Because antennas would be very long at audio frequencies (those below 20,000 Hz), radio transmitters must transmit at frequencies above 20 KHz. These are called *radio frequencies*.

Since high frequencies are used for radio transmission, it is not practical to use RC circuits to control the frequency of the oscillators. Instead, LC resonant circuits or quartz crystals (a form of resonant circuit) are used.

The oscillator in your transmitter will use a Colpitts LC oscillator. This type of oscillator uses a split-capacitor to obtain positive feedback. Its operating frequency is fairly stable compared to other oscillator configurations (Hartley, Armstrong, etc). This means that it will produce a nearly constant frequency output.

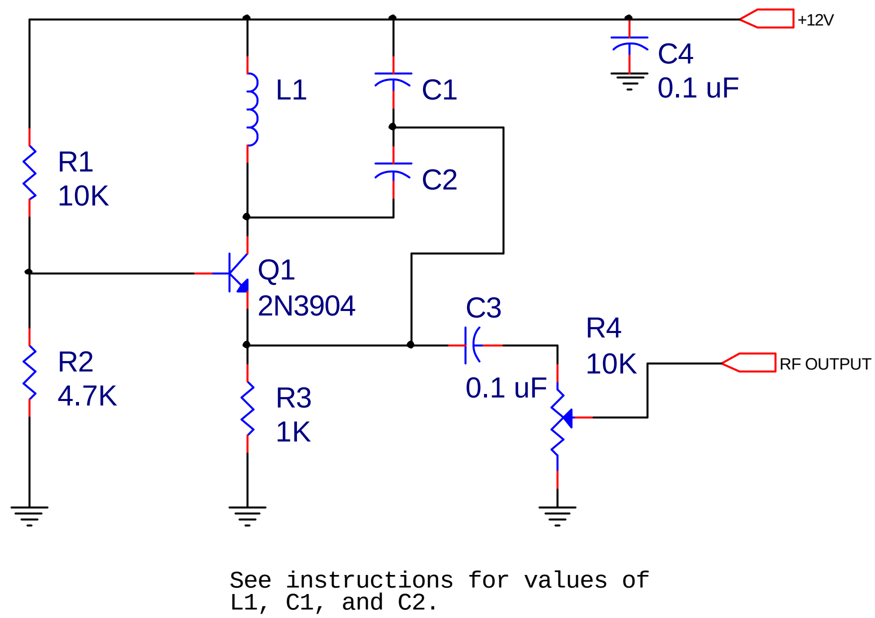


Figure 1: Colpitts Oscillator

CIRCUIT ANALYSIS:

Figure 1 is the oscillator circuit. It is nothing more than a class-A biased transistor amplifier, with an added resonant tank circuit, and a positive feedback path. (Remember that oscillators need positive feedback to operate).

Base bias is (you guessed it), a voltage divider, built from R1 and R2. R3 is used for the emitter bias, while L1, C1, and C2 are used as the resonant circuit to determine the frequency of the oscillator. What parts make up the feedback path?

Right! C1 and C2 are the feedback path. The series capacitors do for AC what series resistors do for DC--they're a voltage divider! Together, their ratio determines the feedback gain. So C1 and C2 have two purposes: They not only control the frequency of the oscillator (together with L1), but they also control the amount of positive feedback in the circuit.

The final output of the oscillator appears at the emitter of Q1. Actually, there will be oscillation at almost every point in this circuit, because it is a closed-loop. By not taking the output directly from the tank circuit, we can reduce the effect that the load resistance will have on the frequency of the tank. This will help make the oscillator frequency more stable, in case the load resistance changes a little.

What is the purpose of potentiometer R4? If you're thinking that R4 adjusts the size of the AC output signal produced by the oscillator, you're right! When we add the modulator stage to the transmitter (experiment 3), it will become important to be able to precisely adjust the carrier voltage. R4 will provide this capability.

RF CONSTRUCTION AND MEASUREMENT PROCEDURES:

A final note: Circuits that operate at radio frequencies ("RF") are very finicky and sensitive. Whenever we build such a circuit, we must always keep our component leads and wiring as short as possible. This reduces unintended inductances and capacitances that might interfere with the circuit operation.

Since RF does tend to radiate freely through space, be sure to keep input and output connections of a circuit apart, unless you want an oscillator!

Finally, RF circuits do not work well when they are "loaded down." When there is excessive stray capacitance to ground, or a small resistance to ground, the circuits may not work as intended. Even the normal oscilloscope leads (1:1) present too much load to the circuits. For this reason, you should always use a 10:1 multiplier probe on any oscilloscope lead used to make measurements in an RF circuit. Such a probe has a 10 meg-ohm input resistance, and reduced input capacitance, to reduce the loading effect on circuits it is used to measure.

LABORATORY PROCEDURE:

Name _______________ Sign-off _________

1. What type of probe should always be used for making an RF measurement?

____

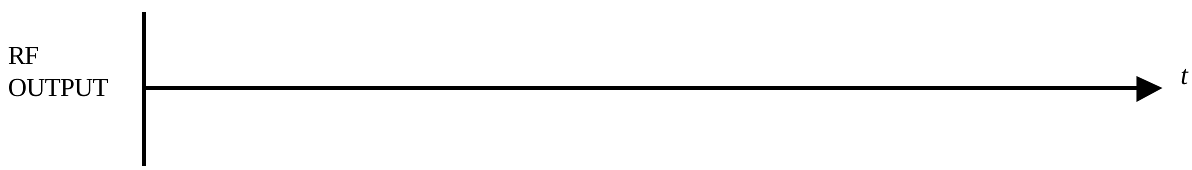
2. Build the circuit of figure 1, using the following values:

C1=0.2 µF   C2=0.1 µF   L1=47 mH

Note: L1 is a blue plastic cylinder that may be marked "347" or "347J."

If there is no 0.2 µF capacitor in the lab kit, can you make one up from some 0.1 µF caps? I thought so!

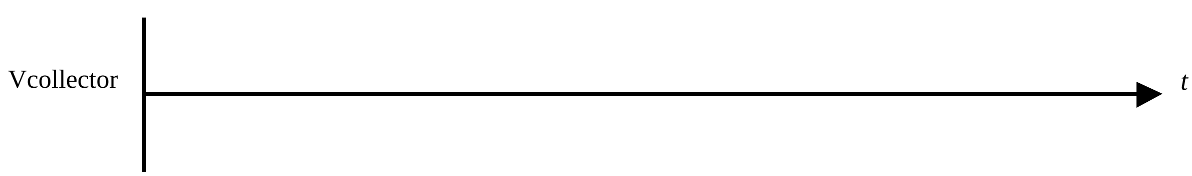
3. Apply power to the circuit, and record the voltage at the *RF OUTPUT* using the oscilloscope. <u>Record two cycles, and show all voltage and time values</u>.



What is the *maximum* output voltage amplitude you can get by adjusting R4?

RF OUTPUT(maximum):__________ V p-p

4. Record the AC collector voltage. Note whether or not it is similar to the other voltages in the circuit (remember, this circuit has feedback!)



5. What is the frequency of the output you measured? _____________

6. Theory tells us that the resonant frequency of L1, C1, and C2 gives the approximate frequency of oscillation for this unit. Can you figure out how to find the resonant frequency of the circuit?

Sure. Start out by writing the general formula for resonant frequency here:

f_0 = ____________________

But this circuit has TWO capacitors! You say they look like they're in *series*? I think you're right! The inductor, L1, sees the series equivalent of C1 and C2....so what is the "C" in your resonant-frequency formula (above) equal to in this case? Show your work below.

Cequiv = ______________________

(Remember, series capacitance is like parallel resistance...)

Now calculate the resonant (and oscillation) frequency of the circuit. Be sure to show your work.

Fosc = f_0 = _________________

Did you get something close to 2.75 KHz? If so, good job!

Is this a radio frequency? _________________

Why or why not? ____

7. We would like to see how close our circuit comes to theory. We do this by computing the percentage of error. It's defined as:

$$\%ERROR = \frac{(measured - calculated)}{(calculated)} \times 100\%$$

Where *measured* is the value read from an actual circuit using test equipment, and *calculated* is the value obtained with pencil and paper. It can be positive or negative error.

What is the percentage of frequency error in your circuit? _____________ %

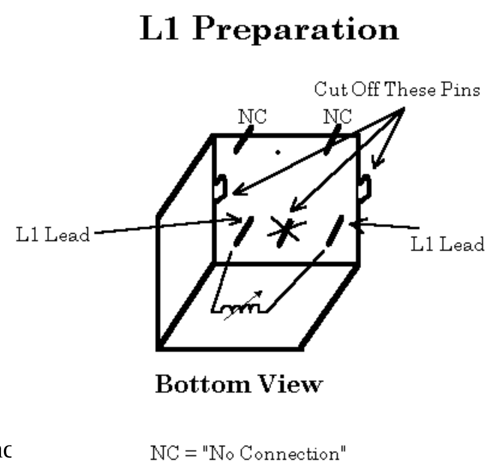
8. Record the information in the table below.

L1	C1	C2	F(calculated)	F(measured)	% Error	RF? (Y/N)
47 mH	0.2 µF	0.1 µF				
10 mH	0.2 µF	0.1 µF				

9. Replace L1 with the *tunable* inductor. You will adjust this inductor by turning the core with the plastic adjustment tool. This should change the operating frequency of the oscillator.

Replace C1 with a 0.002 µF capacitor, and C2 with a 0.001 uF capacitor. Be careful not to get these two mixed up!

TIP: L1 is in a silver "can" and has five component leads and two metal mounting tabs. In order to insert L1 into the breadboard, you will have to cut off one of the leads and both of the mounting tabs as follows:



What is the maximum frequenc

What is the minimum frequency of oscillation? ___________________

What happens to the frequency of oscillation if you put a metal screwdriver into th

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What type of tool do you think is better for adjusting a variable inductor, plastic or

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Important: You should obtain oscillation frequencies in the approximate range of 450 KHz to 680 KHz. If you can't get the circuit to operate within this range, double-check the values of L1, C1, and C2.

Well, it looks like you're off to a good start on the transmitter! <u>*You'll want to save this circuit, you'll need it later on*</u>. Before you go further, it's time to check yourself out by answering the following questions.

QUESTIONS

1. What is meant by the term "Radio Frequencies?"

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2. What components determined the operating frequency of the oscillator you built?

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3. When constructing an RF circuit, what precautions should be taken with regard to wiring and component leads?

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4. Why do you think it might be important that the frequency of the oscillator in a transmitter be stable?

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5. What else have you learned in this lab?

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