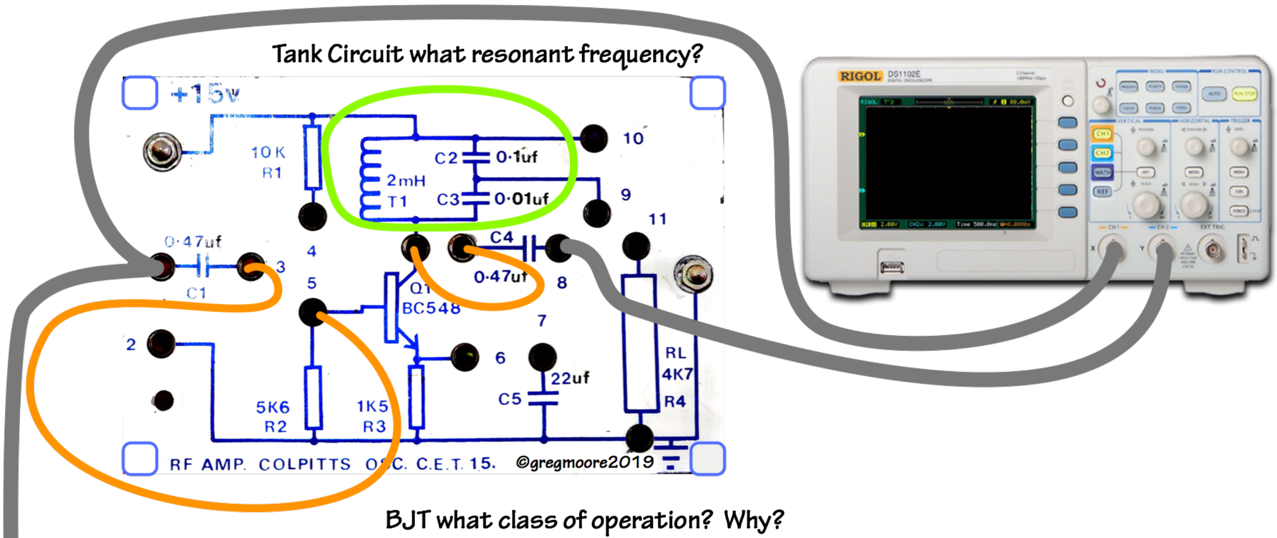
RF Keyed Oscillator Lab

We have previously examined in great detail how the LC tank circuit works and we built a small circuit to examine the damped output waveform on the oscilloscope.

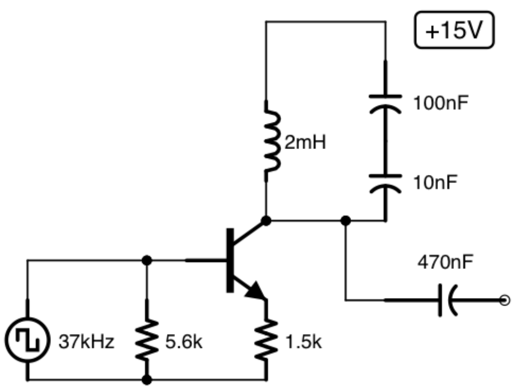
It was shown that if we could pulse the circuit at precisely the right time, we can sustain the oscillation with no decay and therefore have a continuous wave oscillator. (CWO)



See here the layout of the equipment we will use for this lab.

The signal generator will be swept through the calculated resonant frequency of the LC circuit until a peak voltage is obtained on the oscilloscope Channel 2.

The signal generator in Square Wave output shall be set to about 2Vpp as measured and displayed on channel 1 of the oscilloscope.



I've drawn the effective schematic diagram of our test circuit adjacent, which might be clearer than reading the board diagram above.

We'll be using the signal generator and sweeping through a large range of frequencies from say 5kHz to 40kHz. Note we are only interested in square wave keying pulses so as to cause conduction in our BJT.

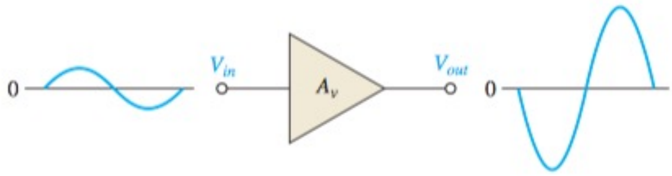
Do you recall the different classes of operation for amplifiers? Class A, Class B, Class AB, Class C and Class D.

This being a tank circuit and able to flywheel for 360º we want to run this circuit in class C, with input pulses only allowing DC to flow in the collector circuit for less than 180º of the cycle. Therefore our keying pulses at the base will be at 50% duty cycle or less.

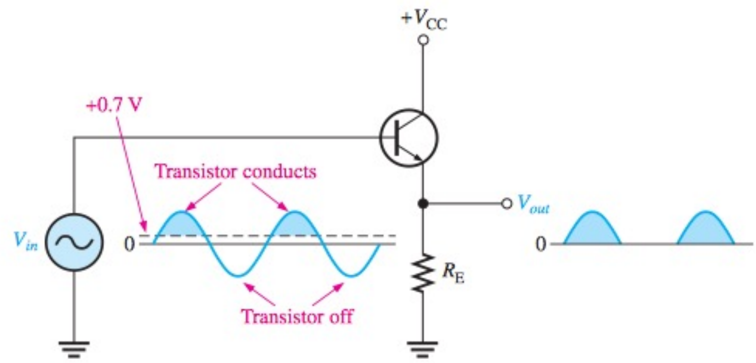
Recall the different classes of amplification. (from Floyd Devices Textbook)

▶ FIGURE 7–1

Basic class A amplifier operation. Output is shown 180° out of phase with the input (inverted).



In Class A, the BJT or active device draws (collector current) for 360º of the cycle.



▲ FIGURE 7–7

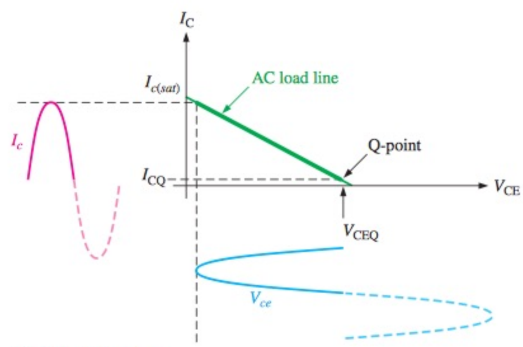
Common-collector class B amplifier.

In Class B adjacent, the transistor conducts for approximately 180º of the cycle (subject to transistor turn on as shown)

Class B and AB are only used in push pull or complementary symmetry situations employing dual output devices.

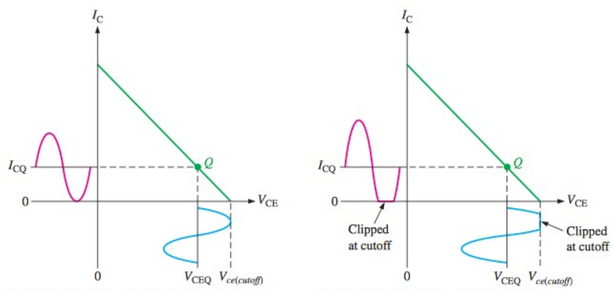
The pink collector current here is of course flowing only when the input voltage is greater than VCE=zero (cutoff), hence the 180º is readily seen.

That is quite different to the diagram 7-3 below where in Class A, if the bias condition shifts the Q point too low on the load line, we see cutoff clipping and distortion. That is completely not good and is the reason why the Q point is midpoint biased in Class A.



(a) AC load line for Q_1

▲ FIGURE 7–14



(a) Amplitude of V_{ce} and I_c limited by cutoff

(b) Transistor driven into cutoff by a further increase in input amplitude

▲ FIGURE 7–3

Q-point closer to cutoff.

In Class C operation, we only see this for RF designs.

Note the RB and -Vbb supply and the fact that the transistor is biased at or beyond cutoff. Note the small conduction angle of the current pulses in the collector current. Here, even there is 360° of input sinewave available to the BJT, only that with exceeds the bias and turn on voltage of the BJT will cause DC conduction in the BJT.

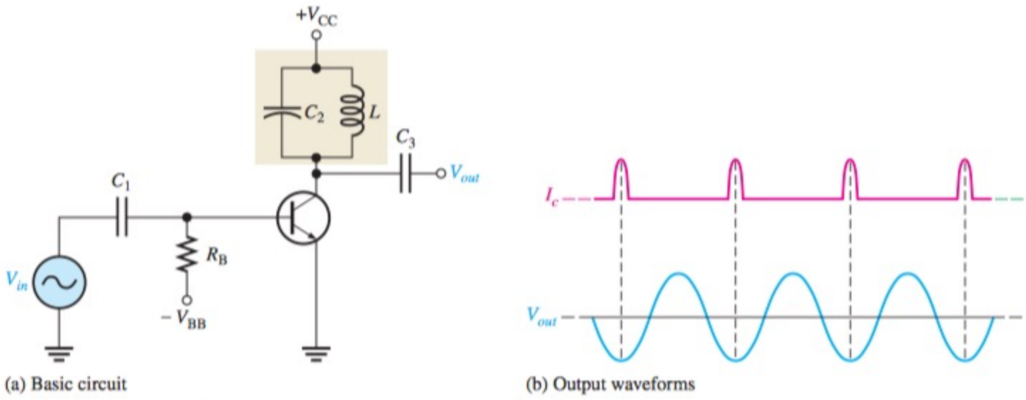


FIGURE 7-24
Tuned class C amplifier.

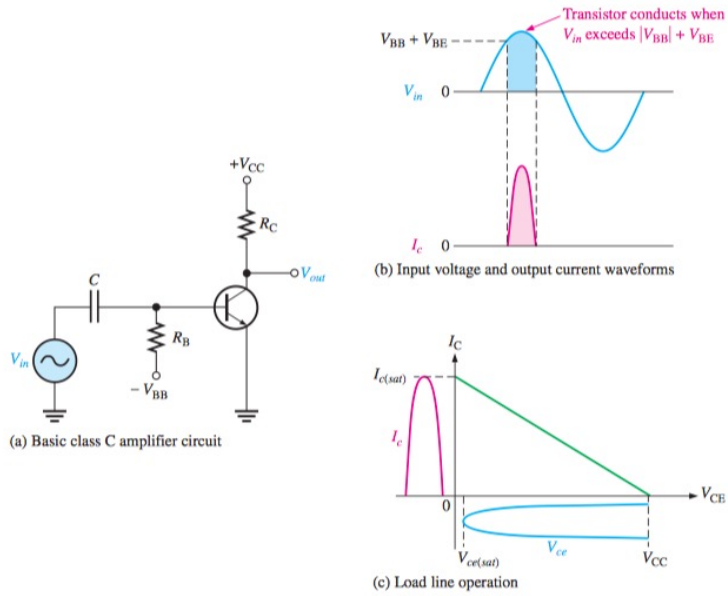


FIGURE 7-22
Basic class C operation.

Most all of these images are small and are only reproduced as a reference that you may read in your prescribed textbook, Electronics Devices by Floyd, the full theory of operation in each case.
Figure 7-25 again reviews the flywheel effect of the tank circuit which we covered in Week 1.

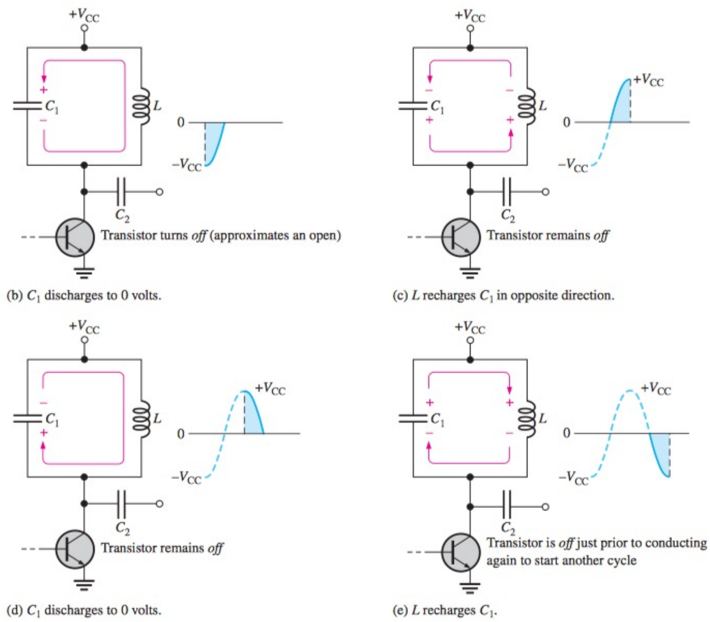


FIGURE 7-25
Resonant circuit action.

Question: Which class of operation is the most efficient?

Well if you said Class C, you are correct. We are getting something for nothing! The stored energy in the inductor and capacitor return energy to the circuit. This is exactly how the inertia of a flywheel in a rotating machine behaves.

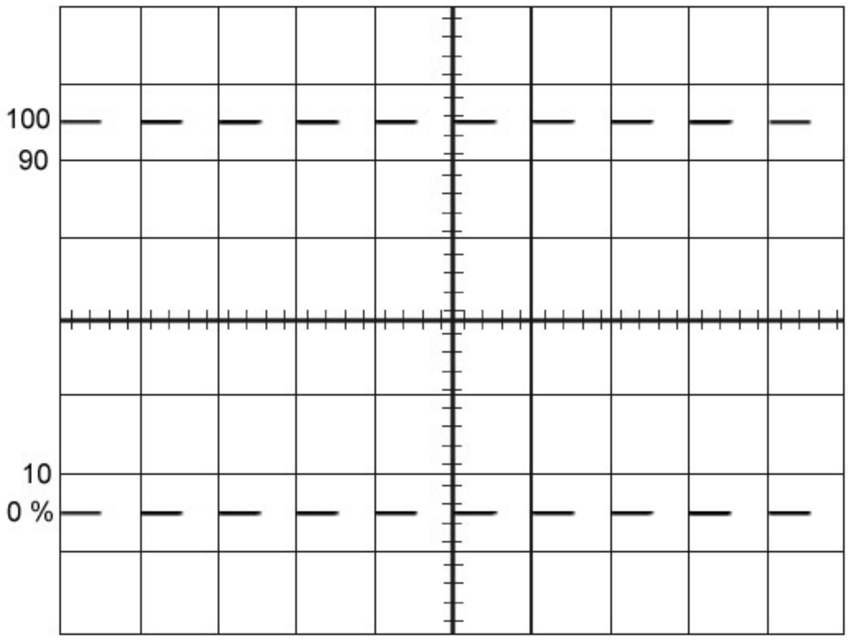
To the Lab:

1. After wiring the board and applying 15Vdc. Do not apply signal generator signal voltage at this time.

Measure the voltage DC at the base of Q1

How is it that this transistor will be able to work with zero bias?

2. Now apply 4Vpp square wave at 5kHz. Draw the waveforms time relevant, label all and show voltages.



Maybe input waveform at the top half of the oscilloscope grid and the output waveform in the bottom half.

It's often a personal preference how the waveforms are shown.

The input waveform will need to be DC coupled as we need to identify the turn on voltage for the transistor. So the input waveform will be measured directly at the base of the transistor. Include all time/ div measurement.

3. Manually sweep the signal generator and observe the peak output voltage. It should peak at around the 38kHz resonant frequency of our tank circuit. (2mH and 0.0090909µF)

The peak output voltage was seen at what frequency?

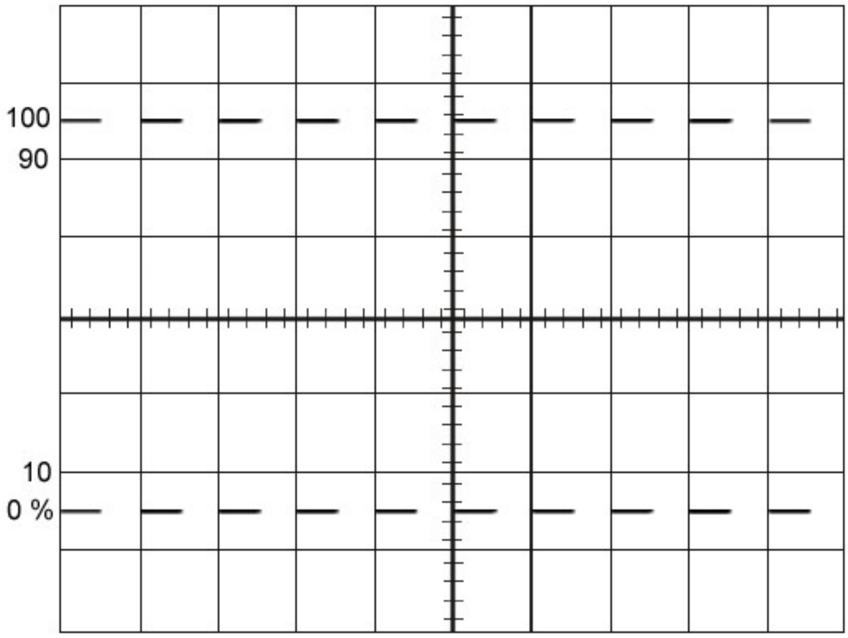
What happened to the shape of the output waveform at the resonant frequency?

What voltage is seen at the collector of Q1 peak to peak at the resonant frequency?

How can the collector voltage be greater than the +15V supplied voltage?

Draw and label your waveforms at the peak output voltage.

Don't forget to include time parameters on your waveforms in addition to voltages.



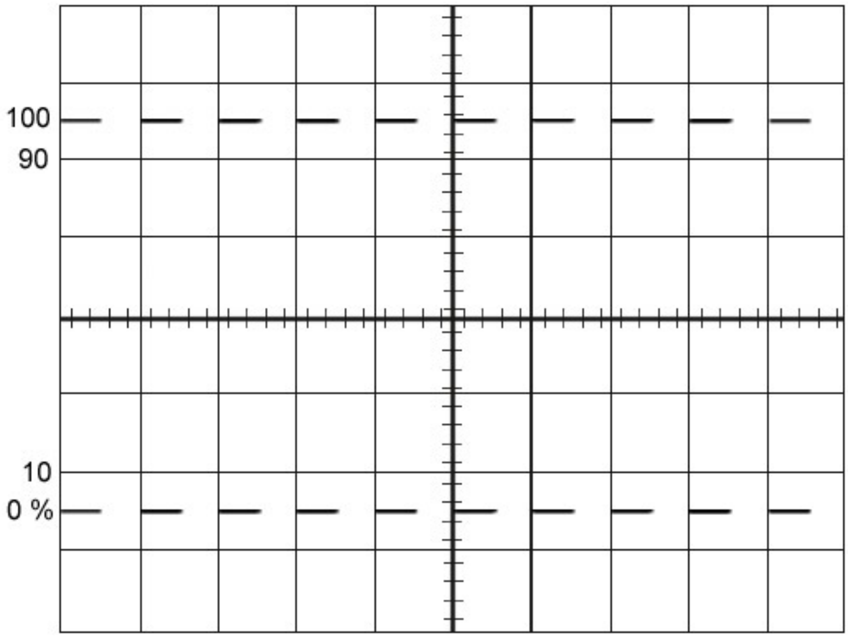
4. Change the duty cycle on your input waveform to approximately 20% on duration.

Vary the duty cycle to 80% on duration.

What do you notice to the output waveform at different duty cycles? Why?

Draw the 20% duty cycle waveforms and be sure to get the phase difference correct.

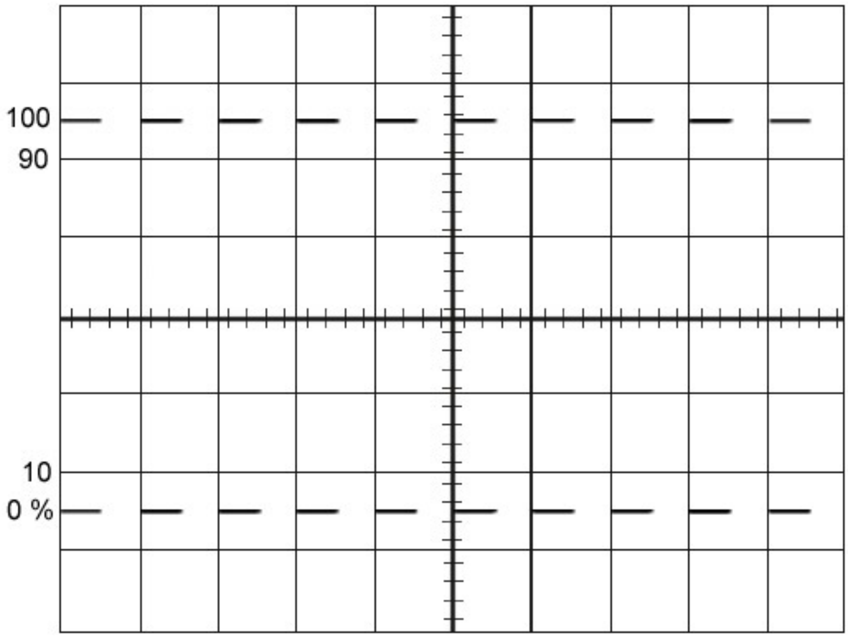
Note the turn on on the BJT and the output waveform coincidence.



Over page for 80% drawing.

Draw the 80% duty cycle waveforms and be sure to get the phase difference correct.

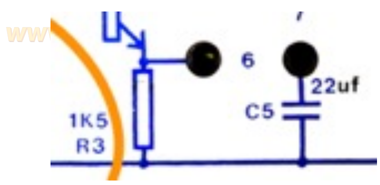
Note the turn on on the BJT and the output waveform coincidence.



5. Add capacitor C5 across R3. What difference do you see in output voltage?

Why?

Now remove C5 from across R3.



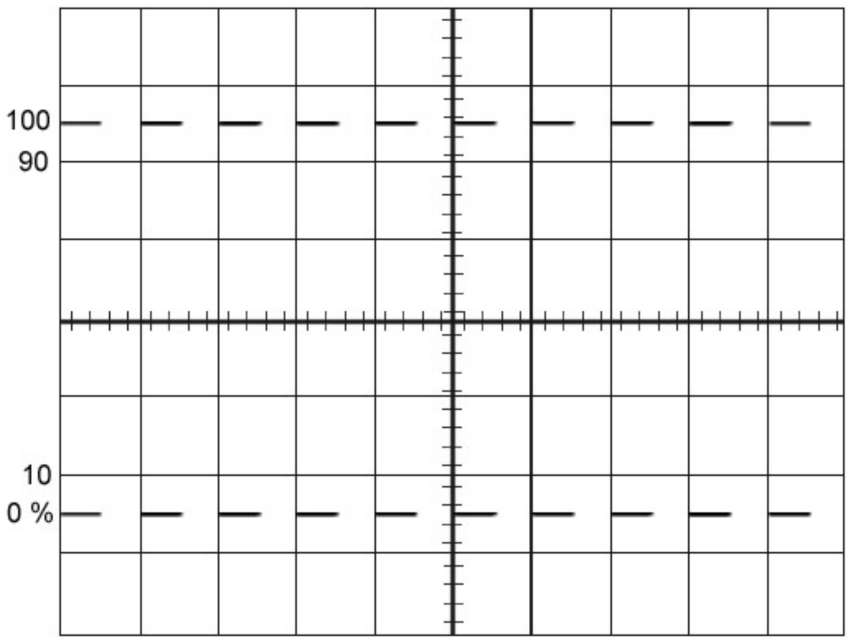
6. Short circuit R3.

Now draw the effect of a short circuit in R3.

Did the linearity of the sine wave at the collector deteriorate ?

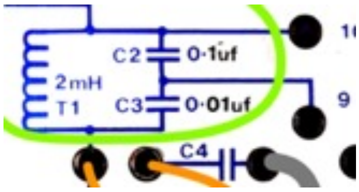
Why?

Did this alter the peak output voltage vs frequency?



7. Remove the short circuit from R3 and now Short circuit C2.

What has changed?



What is the new peak frequency?

Is this higher or lower than previously seen?

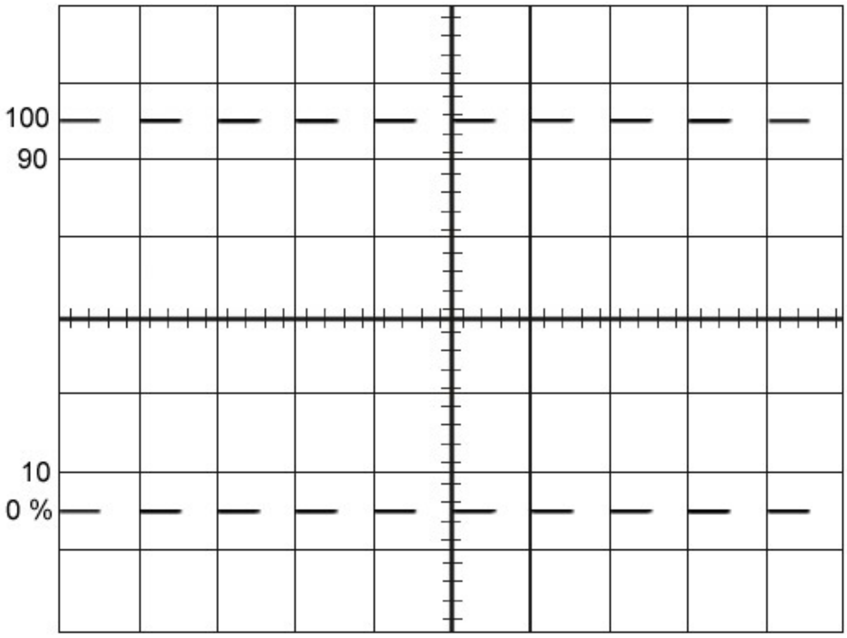
Show the maths for your working here. What is the new effective capacitance across T1 ?

8. Remove the short circuit on C2 and add RL 4.7kΩ into circuit. (pin 11 to pin 8)

Draw the new input and output waveforms with the load on the output of the BJT.

What is the effect called that you see here?

What do we need to use after an oscillator to prevent this effect and another important thing caused by this effect?



What is this other important thing? Is it related to Q in the tank circuit? Does it cause ‘frequency pulling’ ?