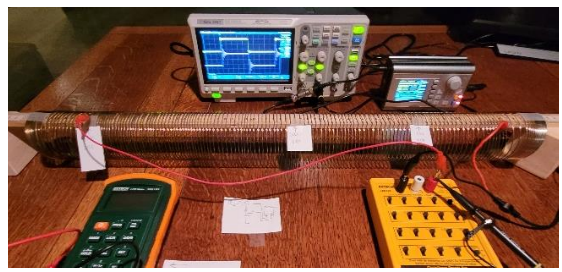
Physics 196 Lab 14: AM Radio Receiver

Equipment:

Item	Part #	Qty per Team	# of Teams	Total Qty Needed	Storage Location	Qty Set Out	Qty Put Back
Oscilloscope	RIGOL DS1102E	1	8	8			
Power cord for Oscilloscope		1	8	8			
Function Generator	PASCO	1	8	8			
Power cord set for Function Generator		1	8	8			
Capacitor Switch Out Box	Extech 380405	1	8	8			
Oscilloscope probes		2	8	16			
Banana/Alligator cords red/black pair		1 pair	8	8 pair			
Germanium Diode		1	8	8			
Slinky + meter stick = Variable Inductor		1 set	8	8 set			
LCR Meter	Extech 380193	1	8	8			
Antenna and Amplified Speaker with cord	Radio Shack	share	8	2 to 4			

Layout:


Measuring Inducance between loops on stretched slinky.


Exciting LC circuit with function generator


Resonance Frequency Measurement


Combining Slinky Inductor, Capacitor and diode to make receiver

Summary: Using a Slinky as a variable inductor, students will make a simple AM radio receiver and verify that it can be tuned to different stations. In the first part of the experiment, resonant frequencies for an LC circuit tuned with different inductance values will be determined by measuring the period of voltage oscillations induced with an external voltage impulse (10 kHz square wave). The inductance will be tuned by connecting to different locations on a slinky. Expected locations for local radio stations will be marked on a meter stick next to the slinky. Then the capacitor and inductor will be reconfigured into a tank circuit and connected to an antenna and a diode with an amplified speaker. Depending on the weather, students will tune in either to simple AM transmitters generating a tone in the lab, or take their circuits up on the roof to try to receive broadcast radio signals.

Prelab:

The AM Frequency Band extends from 540 kHz to 1610 kHz. Some of the AM radio stations that can be received at Miramar College are KOGO (600 kHz), XEWW (690 kHz), KGB (760 kHz), KECR (910 kHz), KCEO (1000 kHz), KURS (1040 kHz), KSDO (1130 kHz), KCBQ (1170 kHz), KPRZ (1210 kHz), KNSN (1240 kHz), KLSD (1360 kHz) and KFSD (1450 kHz). The AM radio reception inside of the lab is very poor, and in order to receive signals we have found it necessary to go up on the roof. In case that is not possible because of the time of day or the weather, the instructor hopes to have three transmitters inside the lab broadcasting tones using AM radio frequencies of 600 kHz, 1000 kHz and 1450 kHz. For a fixed Capacitor Value of 550 pF, in the table below calculate the necessary inductance in an LC circuit to create resonance at those frequencies. Note that the resonant frequency of an LC circuit is given by $f=1/2\pi(LC)^{1/2}$. In addition, calculate the expected oscillation period T=1/f which we will measure by exciting an LC circuit with a square wave impulse, and measuring the period of oscillations on an oscilloscope. (The last column should be filled in for the actual Capacitance value you use during lab).

Frequency (kHz)	L (mH) for C=550 pF	Oscillation Period (mS)	L (mH) for C=______ pF
600			
1000			
1450			

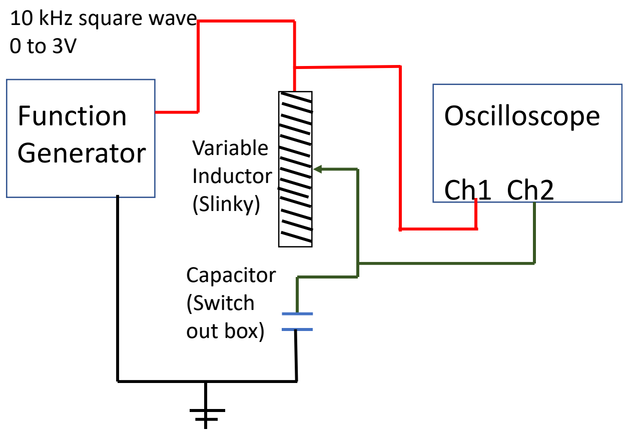
Lab:

In your lab notebook, please include a description and labelled diagram of each part of the experiment, sketches of input and output waveforms, calculations, a discussion of the results in terms of expectations, and a conclusion.

Experiment 1, Measure inductance and mark slinky location for 600, 1000 and 1450 kHz resonance.

Support a meter stick on blocks or stands. Stretch a slinky to a length of about 80 cm on the slinky, taping the ends with blue tape or finding some other way to fix the length. Choose a fixed location at one end of the slinky and mark the location. Attach one lead of the LCR meter at this location. Measure the inductance from this location to somewhere near the other end of the slinky. You will want this inductance to give you a resonant frequency near 600 kHz. Calculate the necessary Capacitance so this is the case. Round up to the nearest capacitance that is a multiple of 100 pF + 50 pF. (That is, 350 pF, 450 pF, 550 pF, etc. --- These are values that can be set with the capacitance switch out box). Write the capacitance in the table above, and calculate the inductances you will need to achieve resonant frequencies of 600, 1000 and 1450 kHz. Now mark the locations on the slinky where you measure those inductances using the LCR meter.

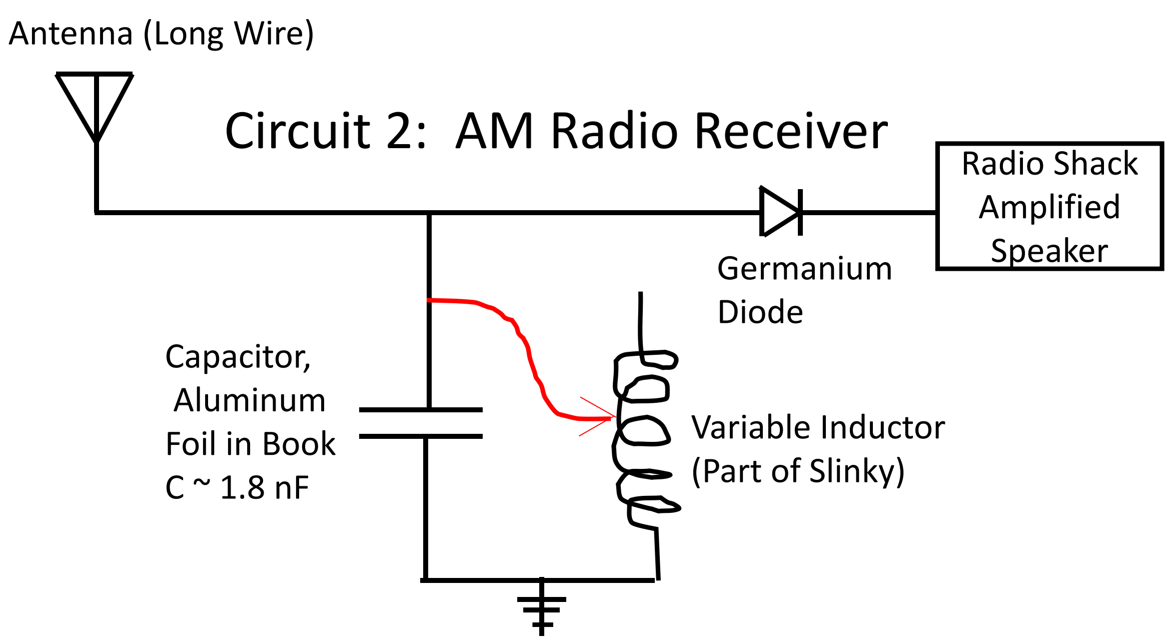
Experiment 2, LC resonance:



Use the function generator to apply a square wave (10 kHz, 0 to 3V using offset) across the inductor and capacitor, with the inductor hooked up at the pick off where you estimated that the resonant frequency would be 600 kHz. Measure the function generator voltage using Channel 1 of the oscilloscope.

Measure the voltage across the capacitor using Channel 2 of the oscilloscope. The traces should look something like those in the 2nd and 3rd picture on the first page. You should see a voltage oscillation at the resonant frequency. Measure the period of this oscillation (time between peaks) and compare it to what you calculated in the prelab. Assuming the period makes sense, quickly verify that the periods look right for when you attach the inductor where you calculated resonance frequencies of 1000 kHz and 1450 kHz as well.

Experiment 3, AM Receiver: To build an AM receiver, we wish to hook an antenna up to part of our LC resonant circuit, and then measure the current in the circuit which should hit maxima when tuned to strong incoming radio signals on the antenna. There are a number of ways in which this might be done, which include building an Operational Amplifier circuit such as the one from Lab 12. However, since we have available a nice packaged audio amplifier from Radio Shack, we will use that. We will couple from the resonant circuit to the amplifier through a Germanium diode, which rectifies the signal. (Before amplifying the signal at audio frequencies, we need to make sure the voltage does not average out to zero.) The audio signal itself is generated at the radio station by varying the amplitude of the carrier frequency. The high frequency (radio frequency carrier) components of the signal are filtered out by the finite response time of the Op Amp and speaker. The circuit looks like the following:



Hopefully we will be able to receive a few radio stations by tuning the inductor (or the capacitor). The reception seems to depend a little bit on atmospheric conditions, time of day, etc. Because the resonances in the circuit are not really sharp, a strong station at a different frequency can overwhelm the station we are trying to hear. Modern radio receiver circuits are more sophisticated than what we have built here. First test out your circuit with the AM transmitters in the lab, which should be set to 600, 1000 and 1450 kHz to make sure you can receive those frequencies by hooking to the pre-marked locations on your slinky.