Germanium Diode Crystal Radio

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Some facts

- First used to receive Morse code signals
- Have since been to pick up vocal broadcasting signals
- No battery power; all energy is from radio waves received by antenna
- Reliable and cheap → popular
- No amplification = weak (quiet) signal

How it works

- 3 main parts
  1. Antenna
  2. Tuning circuit
  3. Semiconductor crystal detector
- Also, to hear the signal you need a speaker or earpiece

Antenna Theory

- Converts energy in electromagnetic radio waves to AC current
- For best performance, antenna length should be $\frac{1}{4}$ of signal wavelength
  - common AM radio frequency (f) range is $(531-1611)kHz$
  - wavelength: $\lambda = \frac{c}{f} = \frac{3 \times 10^8 m/sec}{fHz}$ range $(186-564)m$
  - Ideal antenna length $l = \lambda/4 = (46-141)m$
- Antenna is only "power source" in the circuit
- Larger antenna results in more power (louder signal)

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Our antenna

- We tried two different antennas
  1. 25 ft (7.62 m) of aluminum single strand insulated wire
  2. 72 ft (21.95 m) of copper single strand insulated wire
- Recall that optimal antenna length is between 46-141 m
- Copper wire did much better than the aluminum

Tuning circuit theory

- Consists of an inductor (L) and a capacitor (C)
- Current flows between the capacitor and the solenoid
- Works a lot like a tuning fork (resonance)
- The received signal frequency matches the resonant frequency of the LC circuit ($f = \frac{1}{2\pi\sqrt{LC}}$)
- Different "loops" on the solenoid allow the user to change inductance ($L = \frac{\mu N^2 A}{l}$) and therefore change resonant frequency

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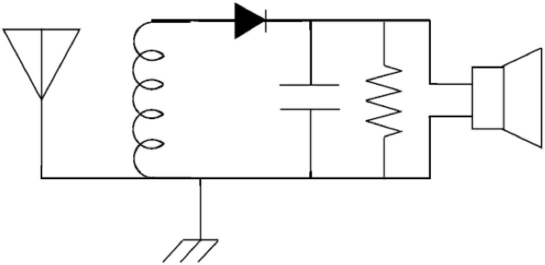
Our tuning circuit

- To build the tuning circuit, we followed this circuit diagram



- Our solenoid has 60 turns ($N = 60$)
- Capacitor value: 0.001 μF
- Resistor value: 82 $k\Omega$

Semiconductor crystal detector

- Rectifies the AM frequency leaving only positive frequency components
- This frequency is is then filtered with a resistor and capacitor and fed to audio device
- Old crystal radios used Galena (lead sulfide), but that isn't the most efficient
- Germanium diodes are optimal because a low forward voltage drop makes them more sensitive
- We used a NTE109 Germanium diode (fast-switching)

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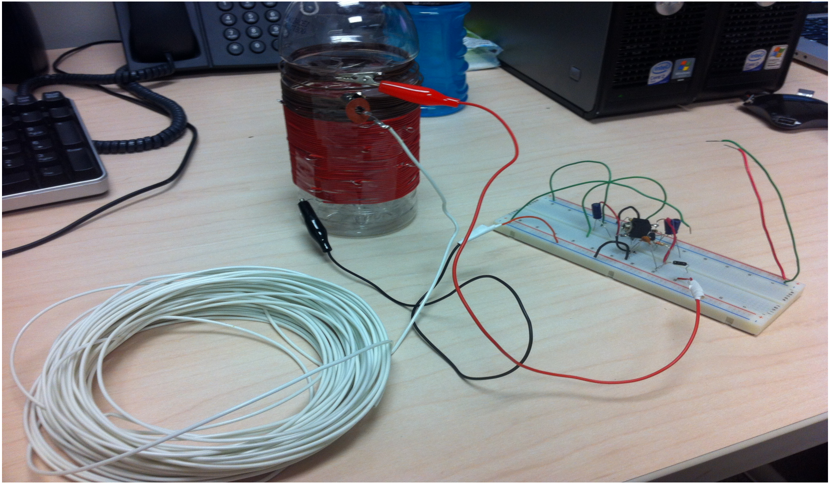
Audio output

- We initially tried headphones, but they didn't work
  - Input impedance was too low
  - No signal or sound amplification
- We then used externally powered speakers
  - Much better because impedance was very high
  - External power amplified the sound signal

The Final Product



Demo

- Tune in to 1280 The Zone!

Interpretation

- There are many ways we could improve our radio
  - Tune the antenna with capacitor which increases the signal/noise ratio
  - We have single capacitor for filter, using a variable capacitor would allow us to pick up different frequencies
  - Include a signal (or audio) amplifier to make signal to the audio device stronger
  - Build a larger solenoid and/or use longer antenna

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