Amateur Wireless Station Operators License Exam

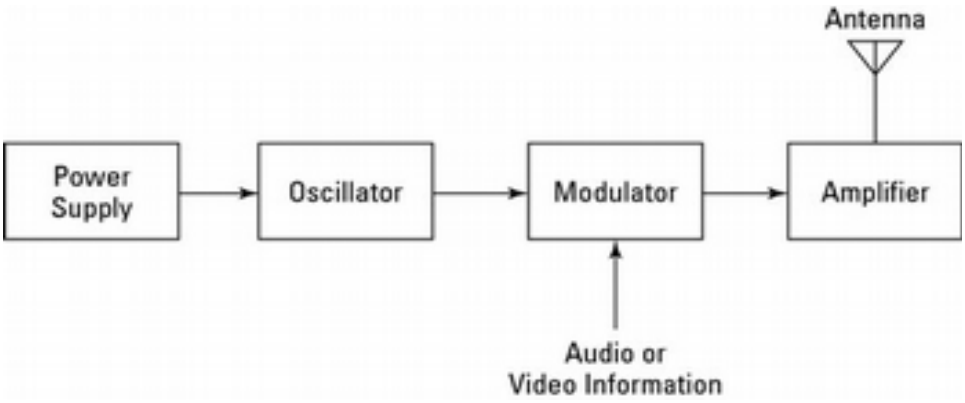
Study material 2017

CHAPTER 5

Chapter 5-Transmitter

Radio transmitters

A radio transmitter consists of several elements that work together to generate radio waves that contain useful information such as audio, video, or digital data.



Power supply: Provides the necessary electrical power to operate the transmitter.

Oscillator:

An electronic oscillator is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave. Oscillators convert direct current (DC) from a power supply to an alternating current signal. They are widely used in many electronic devices. Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video games.

Oscillators are often characterized by the frequency of their output signal:

- An audio oscillator produces frequencies in the audio range, about 16 Hz to 20 kHz.
- An RF oscillator produces signals in the radio frequency (RF) range of about 100 kHz to 100 GHz.
- A low-frequency oscillator (LFO) is an electronic oscillator that generates a frequency below ≈20 Hz. This term is typically used in the field of audio synthesizers, to distinguish it from an audio frequency oscillator.

*Oscillators designed to produce a high-power AC output from a DC supply are usually called **inverters.***

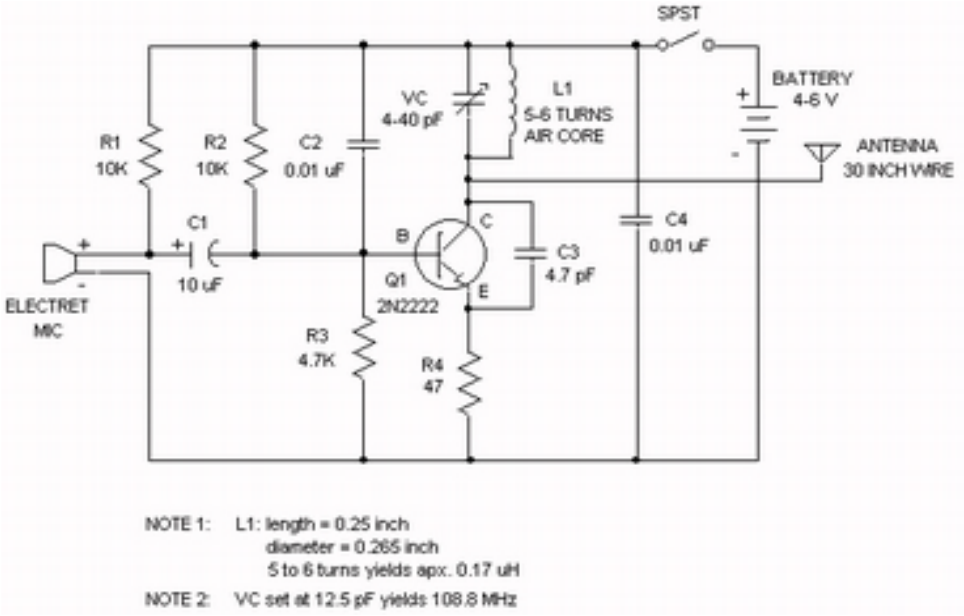
Modulator: Adds useful information to the carrier wave. There are two main ways to add this information. The first, called amplitude modulation or AM, makes slight increases or decreases to the intensity of the carrier wave. The second, called frequency modulation or FM, makes slight increases or decreases the frequency of the carrier wave.

Amplifier: Amplifies the modulated carrier wave to increase its power. The more powerful the amplifier, the more powerful the broadcast.

Antenna: Converts the amplified signal to radio waves.

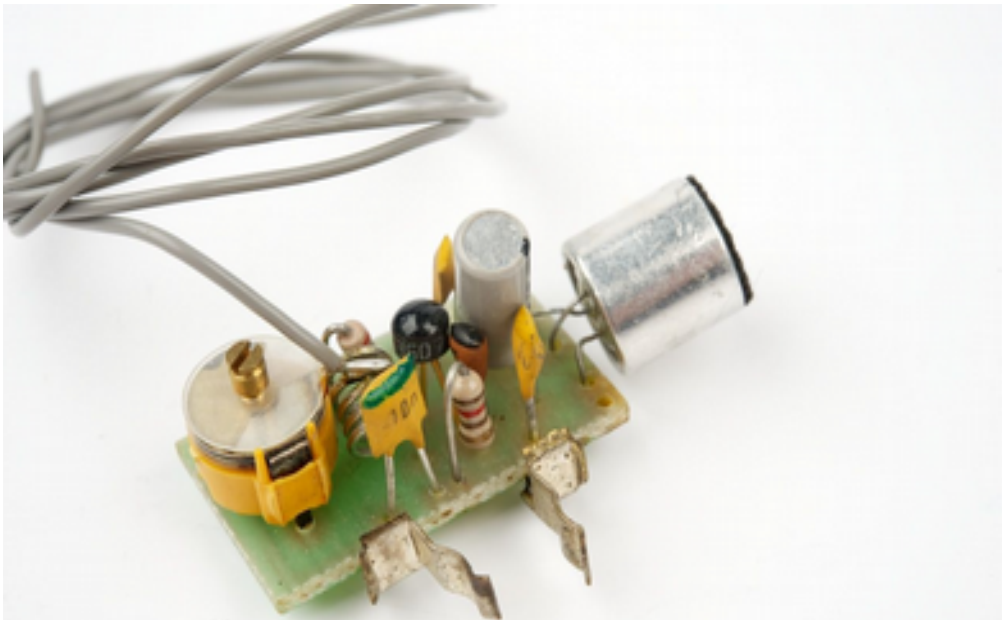
A simple FM transmitter/FM bug

The schematic diagram of an FM room bug/transmitter is given below.



How does this Transmitter Work?

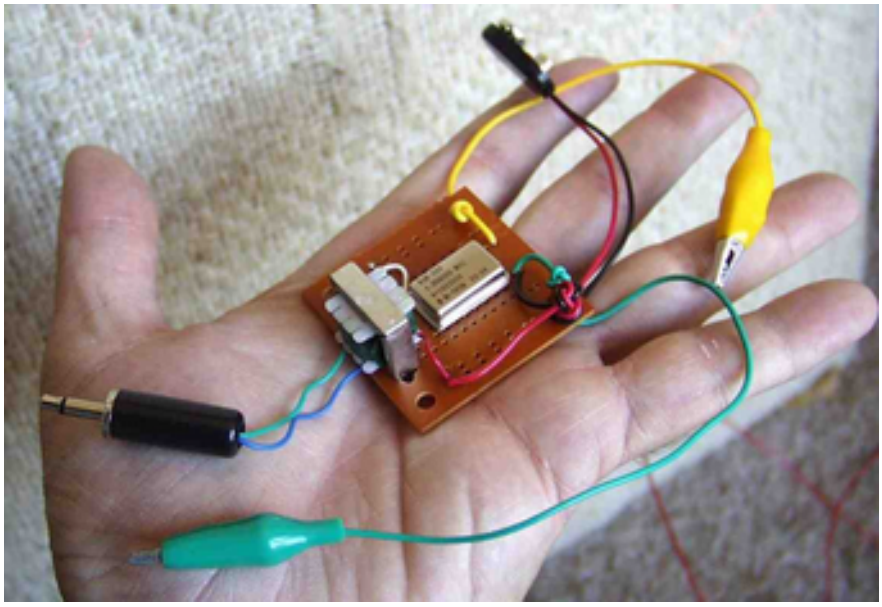
The variable capacitor and your inductor will oscillate at frequencies in the FM radio band (88 to 108 MHz). The electret microphone has a resistance that depends on how loudly you speak into it. This microphone is battery powered and according to the V=IR Ohm's Law, changes in resistance for fixed voltage will result in proportional changes in current. This current feeds into the base of the 2N2222 NPN transistor which is connected to your variable capacitor, inductor and antenna. The net effect is that depending on your variable capacitor's value, your voice will be modulated to transmit at a frequency between 88 and 108 MHz. If a nearby pocket FM radio is tuned to this frequency, you'll be heard when speaking into your transmitter.



Building your AM radio station

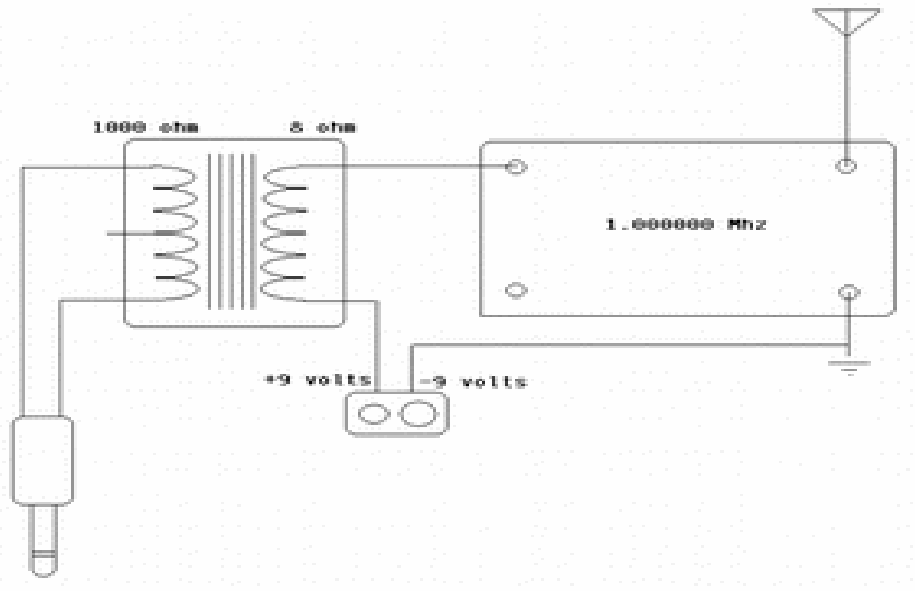
If a crystal radio is the distilled essence of a radio, this transmitter is the matching distilled essence of transmitters. The transmitter goes together in about 10 minutes, and is small enough to fit in the palm of your hand. Depending on the antenna, the transmitter can send voice and music across the room, or across the street.

Our transmitter will need these parts:



- **A one megahertz crystal oscillator :**This is a crystal clock oscillator such as those used in computers,which is available in the local market
- **An audio transformer :**This is a 1000 ohm to 8 ohm audio transformer,
- **A generic printed circuit board :**Any general purpose printed circuit board will do.
- **A phone plug** :This should match the jack in your sound source. plug to match standard earphone jacks of transistor radios or your mobile phone.
- A 9 volt battery clip ,A 9 volt battery ,A set of alligator jumpers,Some insulated wire for an antenna. You can use the same antenna you used for the crystal radio.

Building the transmitter :



The Crystal oscillator is the heart of the transmitter. It has four leads, but we only use three of them. When the power is connected to two of the leads, the voltage on third lead starts jumping between 0 volts and 5 volts, one million times each second.

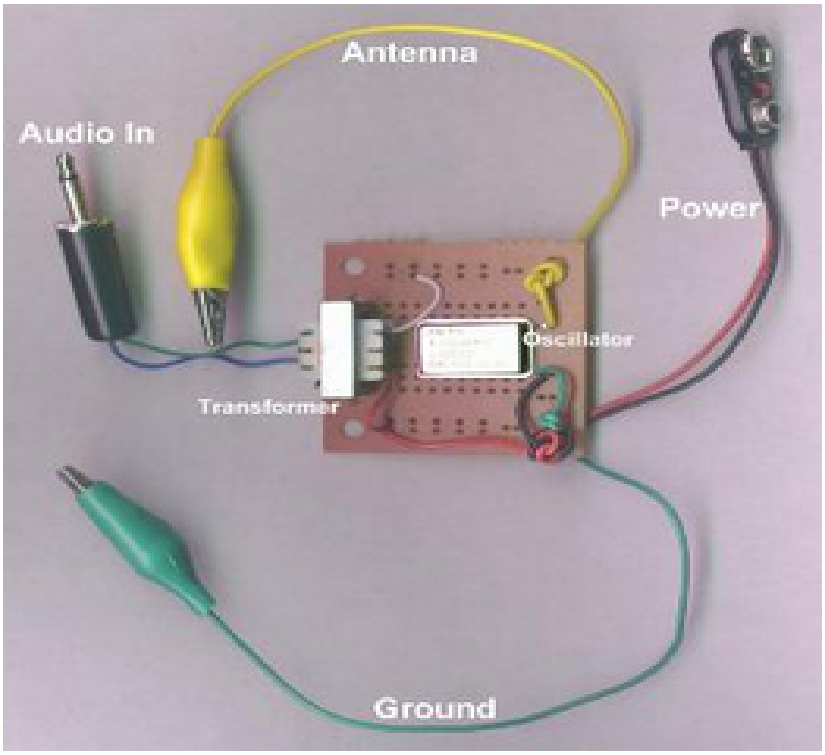
The oscillator is built into a metal can. The corners of the can are rounded, except for the lower left corner, which is sharp. This indicates the where the unused lead is. The lead is there to help hold the can down firmly on the printed circuit board, but it is not connected to anything inside the can.

The other main part is the audio transformer . In this circuit it is used as a modulator. The modulator changes the strength of the radio waves to match the loudness of the music or voice we want to transmit.

Assemble the radio as shown in the schematic diagram and you are ready to test your little radio station!

Using the transmitter

We are now ready to test the transmitter. Plug the phone plug into the earphone jack of a convenient sound source, such as a transistor radio, tape player, or CD player.



Plug the battery into the battery clip.

Hold the transmitter near an AM radio, and tune the radio to 1000, so you can hear the your sound source in the AM radio. Adjust the volume controls on the sound source and on the AM radio to get the best sound.

Without any connection to an antenna or a good ground connection, the transmitter will only transmit to a receiver a few inches away. To get better range, clip the ground wire to a good ground, such as a cold water pipe, and the antenna to a long wire, like the one we used for the crystal radio.

How it works?

A crystal oscillator (sometimes abbreviated to XTAL on schematic diagrams) is an electronic circuit that uses the mechanical resonance of a physical crystal of piezoelectric material along with an amplifier and feedback to create an electrical signal with a very precise frequency. It is an especially accurate form of an electronic oscillator. This frequency is used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to

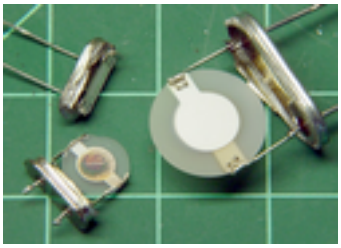
stabilize frequencies for radio transmitters. Crystal oscillators are a common source of time and frequency signals. The crystal used therein is sometimes called a "timing crystal"

In our Circuit,The crystal oscillator is connected to one end of a long wire antenna. It alternately applies 9 volts of electricity to the end of the wire, and then 0 volts, over and over again, a million times each second.

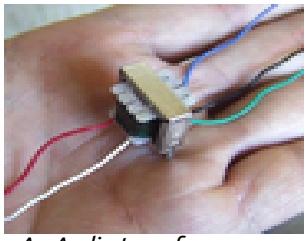
The electric charge travels up and down the wire antenna, causing radio waves to be emitted from the wire. These radio waves are picked up by the AM radio, amplified, and used to make the speaker cone move back and forth, creating sound.

The sound source you are using (your CD player, or tape recorder or your mobile phone) is normally connected to drive a speaker or earphone. It drives the speaker by emitting electricity that goes up and down in power to match the up and down pressure of the sound waves that were recorded. This moves the speaker in and out, recreating the sound waves by pushing the air in and out of your ears. But In our transmitter, the sound source is connected to the audio transformer instead of to a speaker. The transformer is connected to the power supply of the oscillator. The sound source causes the transformer to add and subtract power from the oscillator, just as it would have pushed and pulled on the speaker. As the power to the oscillator goes up and down, the power of the electricity in the antenna goes up and down as well. The voltage is no longer simply 9 volts. It is now varying between 0 volts and 9 volts, because the power from the transformer adds and subtracts from the power of the battery.

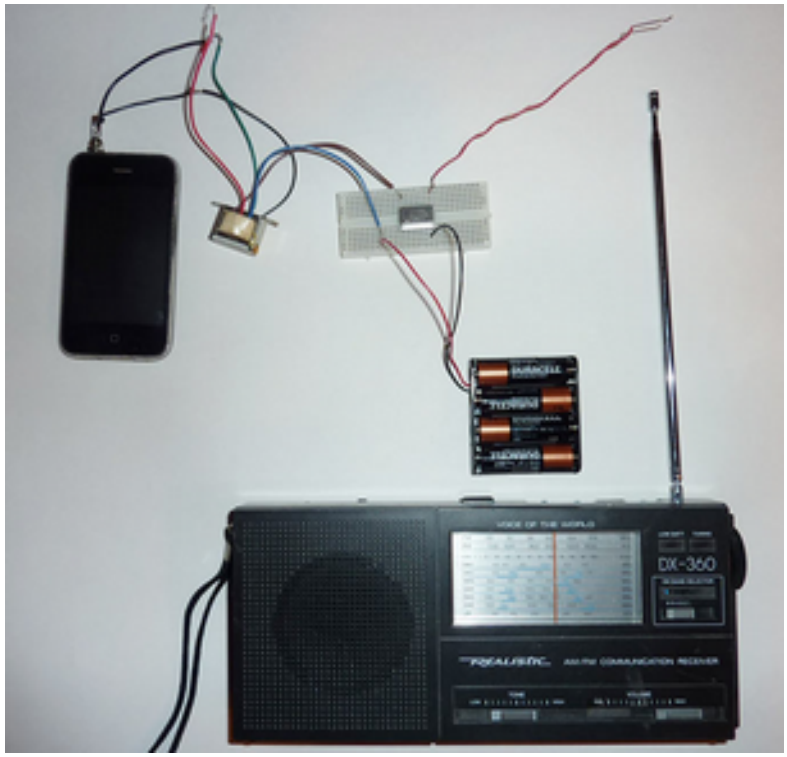
The varying power in the antenna causes radio waves to be emitted. The radio waves follow the same curves as the waves in the antenna. However, because the transmitter and the receiver are not connected, the receiver does not know what the transmitter is using for the value of zero. All the receiver sees is a radio wave whose amplitude is varying. The detector in the radio(see the crystal radio section) detects the signal and reproduce the song we are playing from our mobile phone :)



Crystal oscillator(below) and its exploded view(above)



An Audio transformer



A Homebuilt AM transmitter with an IPhone playing a song

Multiple Choice Questions

1. If a dial marked in megahertz shows a reading of 3.525 MHz, what would it show if it were marked in kilohertz?

a) 35.25 kHz
b) 3525 kHz
c) 3 525 000 kHz
d) 0.003525 kHz

Mega is a million, kilo is a thousand. A Megahertz is a thousand kilohertz. Converting from Megahertz to kilohertz, from large units to smaller, requires more digits, decimal point moves to the right by three positions, a thousand times more.

2. One megahertz is equal to:

a) 1 000 kHz
b) 100 kHz
c) 0.001 Hz
d) 10 Hz

Mega is a million, kilo is a thousand. Converting from Megahertz to kilohertz, from large units to smaller, requires more digits, decimal point moves to the right by three positions, a thousand times more.

3. What is the name for the distance an AC signal travels during one complete cycle?

a) **Wavelengt**h
b) Wave speed
c) Waveform
d) Wave spread

Wavelength: the distance between successive points of equal amplitude and phase on a wave (for example, crest to crest or trough to trough).

4. What happens to a signal's wavelength as its frequency increases?

a) It gets longer
b) It stays the same
c) It disappears
d) It gets shorter

Wavelength (lambda) in metres is 300 divided by frequency in Megahertz (i.e., the speed of light divided by the frequency in Hertz). Wavelength and frequency have an inverse relationship.

5. How fast does a radio wave travel through free space?

a) At the speed of light
b) At the speed of sound
c) Its speed is inversely proportional to its wavelength
d) Its speed increases as the frequency increases

6. What are the frequency limits of the VHF spectrum?

a) 30 to 300 kHz
b) **30 to 300 MHz**
c) 300 to 3000 kHz
d) 300 to 3000 Mhz

7. What are the frequency limits of the UHF spectrum?

a) 30 to 300 kHz
b) 30 to 300 MHz
c) 300 to 3000 kHz
d) 300 to 3000 MHz

8. What frequency range is referred to as HF?
a) 300 to 3000 Mhz
b) 30 to 300 MHz
c) 3 to 30 MHz
d) 300 to 3000 kHz

9. Which of the following is a form of amplitude modulation?
a) Spread-spectrum
b) Packet radio
c) Single sideband
d) Phase shift keying

10. What type of modulation is most commonly used for VHF packet radio transmissions?
a) FM
b) SSB
c) AM
d) Spread Spectrum T

11. Which type of voice modulation is most often used for long-distance or weak signal contacts on the VHF and UHF bands?
a) FM
b) AM
c) SSB
d) PM

12. Which type of modulation is most commonly used for VHF and UHF voice repeaters?
a) AM
b) SSB
c) PSK
d) FM

13. Which of the following types of emission has the narrowest bandwidth?
a) FM voice
b) SSB voice
c) CW
d) Slow-scan TV

14. Which sideband is normally used for 10 meter HF, VHF and UHF single-sideband communications?
a) Upper sideband
b) Lower sideband
c) Suppressed sideband
d) Inverted sideband

15. What is the primary advantage of single sideband over FM for voice transmissions?
a) SSB signals are easier to tune
b) SSB signals are less susceptible to interference
c) SSB signals have narrower bandwidth
d) All of these choices are correct