The Razzmatazz of Radio

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Wednesday, March 29, 2017

The Razzmatazz of Radio

Three Chapters to Present

- A Brief History Of Radio Development – 10 min
- Radio Types and Modulation Formats – 30 min
- Example Radio Circuits – 20 min

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A Brief History Of Radio Development

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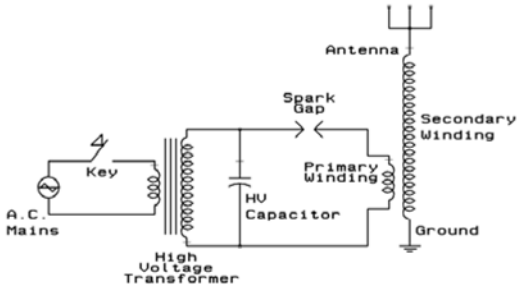

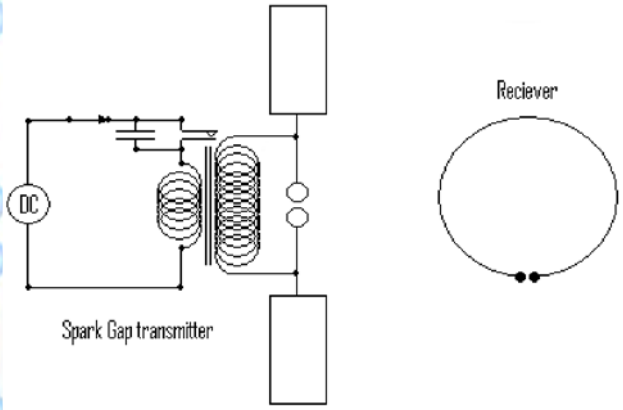

- **1780-1784:** George Adams see sparks between conductors when a “Leyden jar” was discharged (Wikipedia)
- **1835**: Peter Samuel Munk Invents the “Coherer” for Reception (Wikipedia)
- **1864**: James Clerk Maxwell – Presents his Paper on Electromagnetic Theory – Equations used Today
- **1893:** Nikola Tesla delivers a lecture "On Light and other High Frequency Phenomena" – But for Power Transmission
- **1896:** Marconi awarded a radio patent - British Patent 12039
- **1898:** Marconi opened the first radio factory, on Hall Street, Chelmsford, England, employing around 50 people

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- 1894 the Italian inventor Guglielmo Marconi built the first complete, commercially successful wireless telegraphy system based on airborne Hertzian waves (radio transmission).
- Lower left – Marconi Demonstrates His Radio Apparatus to Inspectors

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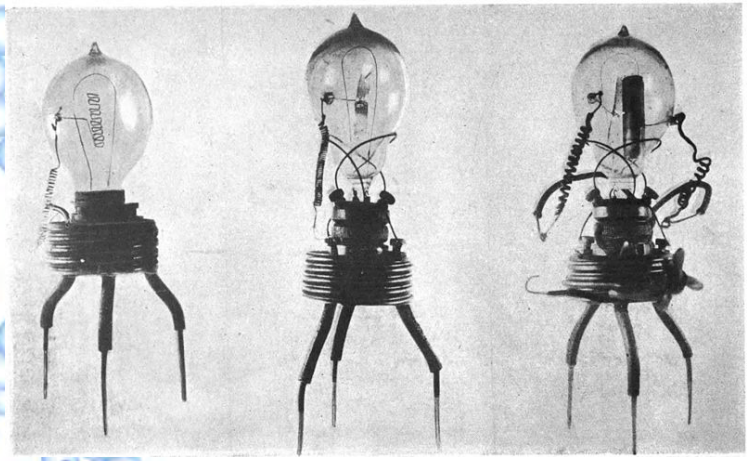

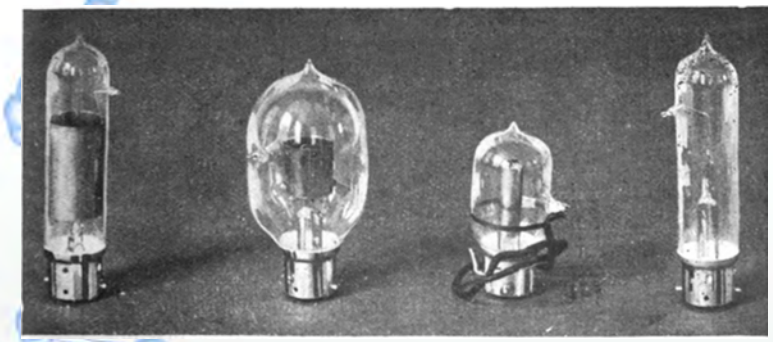

- George Adam's Spark Gap Receiver Demonstrated Radio Feasibility
- Peter Munk's Coherer Demonstrated Practical Reception (Morse Code)
- Fleming's Vacuum Diode Improved Radio Sensitivity and Convenience
- This Also Paved The Way For Voice Reception - Amplitude Modulation (AM) – Triode Amplifier - Precursor

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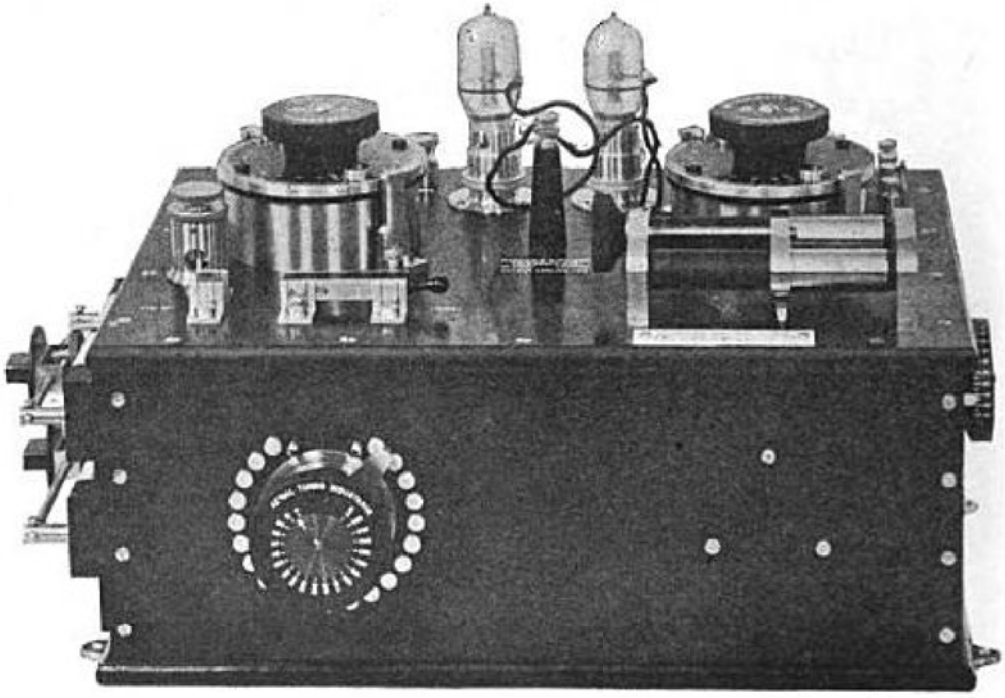

- Early AM Radio Receiver
- Used Two “Fleming” Diode Valves, Invented 1904
- Dual Redudency – In Case One Valve “Burns Out”
- Thermonic Emission Discovered Much Earlier by Frederick Guthrie, 1873.

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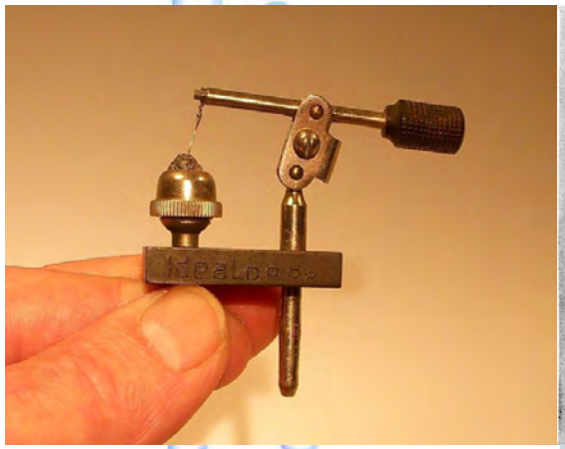

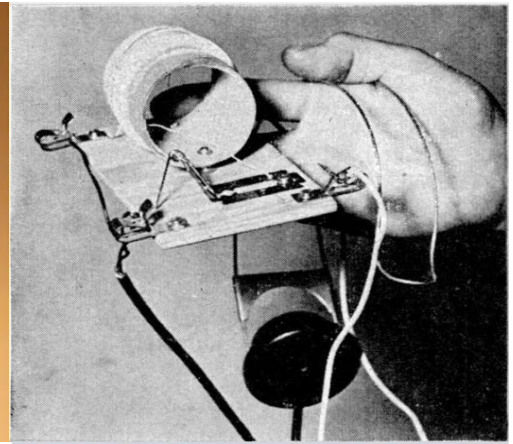

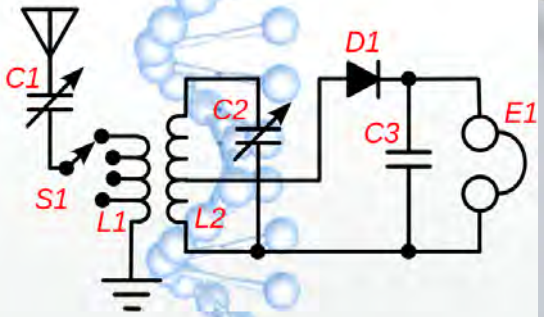

- Vacuum Tube Diodes Were Popular but Consumed Power
- People Sought Low Power “Solid State” Alternative - Galena
- WW2 “Foxhole” Crystal Radio
- Diode Made From Pencil Lead and a Razor Blade (rusty?)
- “Modern” Germanium Diode

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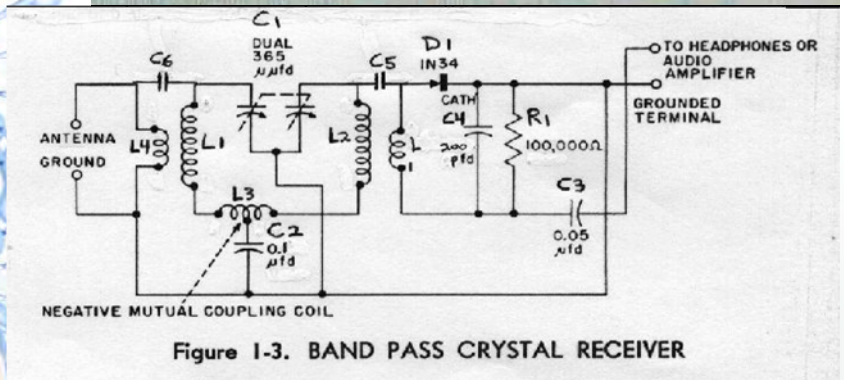

Figure 1-3. BAND PASS CRYSTAL RECEIVER

- Vacuum Tube Diodes Were Popular but Consumed Power
- People Sought Low Power “Solid State” Alternative - Galena
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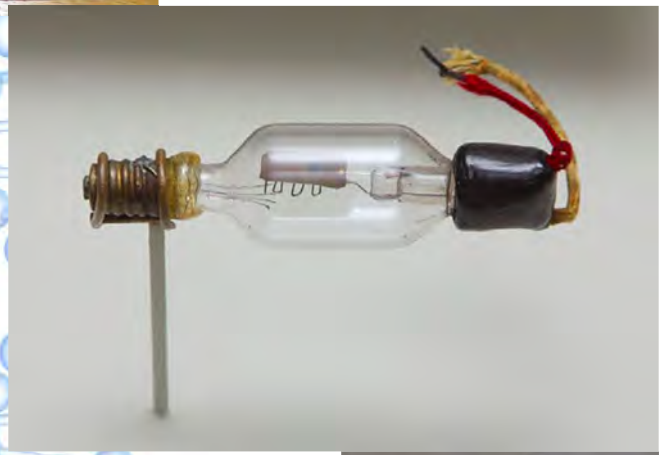
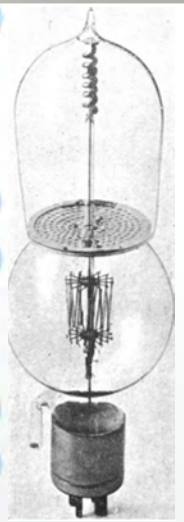


- Lee De Forest's 1904 “Audion” radio wave detector “Triode” Valve
- Robert von Lieben – Invented Same Time
- First Device for ***Amplification***
- Actual Operation was Poorly Understood – Early Triodes Had a “Soft Vacuum” —> “Hard Vacuum” Valves Came Later.



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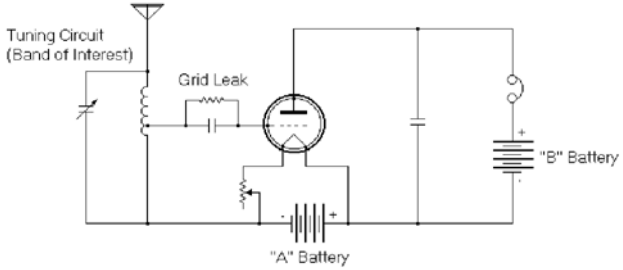

- Lee De Forest's 1904 “Audion” radio wave detector Triode Valve
- Robert von Lieben – Discovered Triode Amplification - Same Time
- ***Amplification*** – Broadcast AM
- Ever Increasing Popularity & Ever Increasing Excess!

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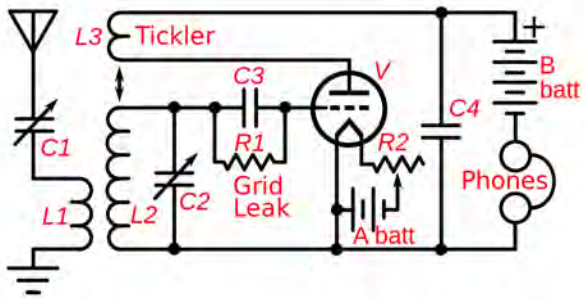
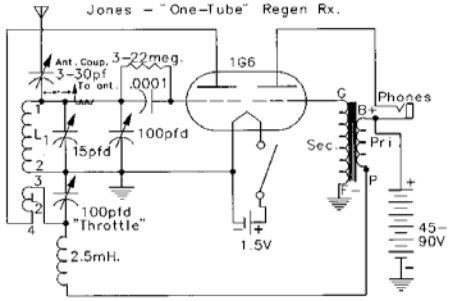




Coil Winding Data: All coils on 1.5" dia. Form

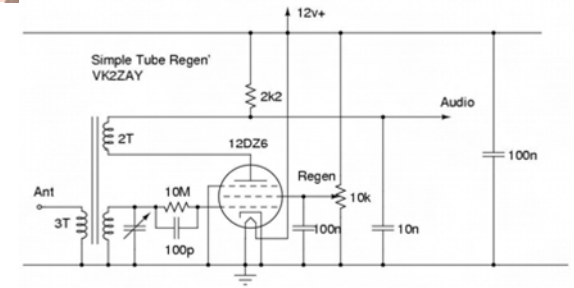
160: L1= 60t #22, close wound
L2= 17t #32, close-wound, 1/8" from L1

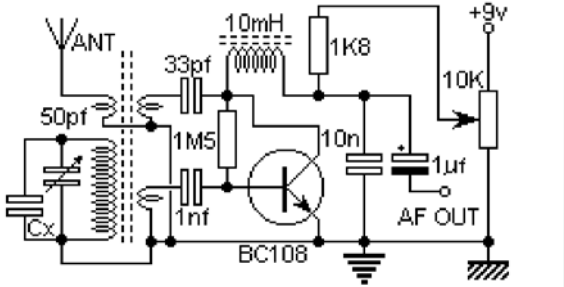
80: L1= 27t #22, close-wound
L2= 11t #22, close-wound, 1/8" from L1

40: L1= 14t #22, close-wound
L2= 7 t #22, close-wound, 1/8" from L1

20: L1= 7 t #22, close-wound
L2= 5 t #22, close-wound, 1/8" from L1

All coils wound in same direction on forms
Audio trans. is 3:1 audio
Keep ant. coupling cap as SMALL as possible 1 to 3 pfd is ample with high values of grid leak resistor. Or use two or three turns of insulated hook-up wire around the grid lead.





- Regenerative Receiver – Edwin Armstrong's First Invention
- Invented 1912, Undergraduate at USA Columbia University
- Edwing Lodged Patent 1914
- Uses "Positive Feedback"
- Improved Sensitivity, Selectivity

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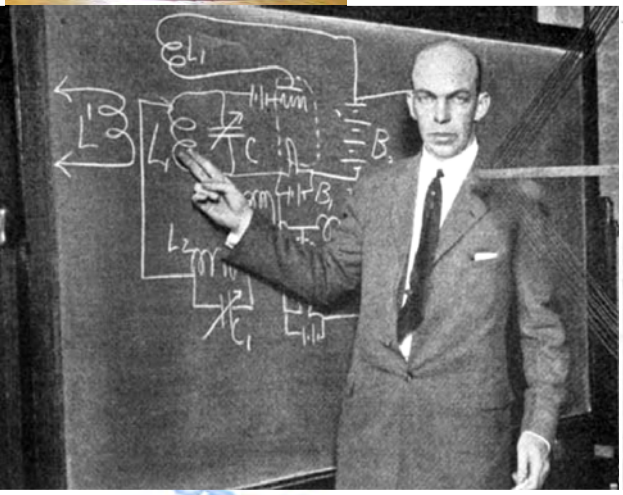
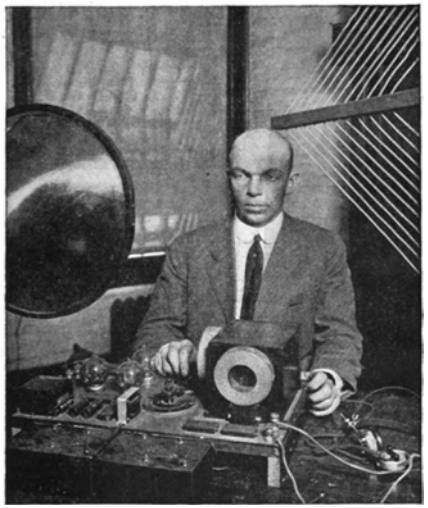
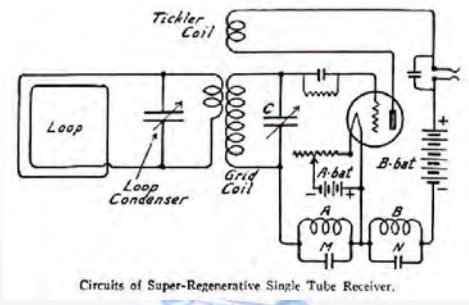




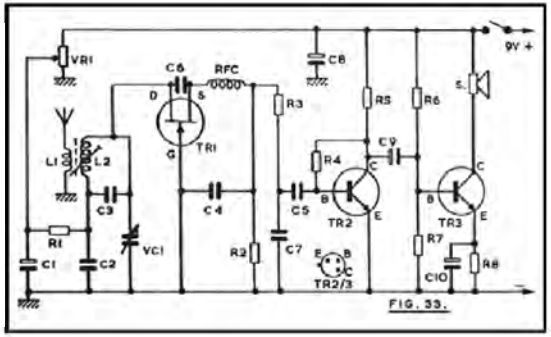
- Super-Regenerative Receiver –

  Invented by Edwin Armstrong 1922

- Useful at VHF, AM, Slope Detect FM
- "Edwin Armstrong presents his superregenerative receiver at the June 28, 1922 meeting of the Radio Club of America in Havemeyer Hall, Columbia University, New York. His prototype 3 tube receiver was as sensitive as conventional receivers with 9 tubes" - Wikipedia



Circuits of Super-Regenerative Single Tube Receiver.



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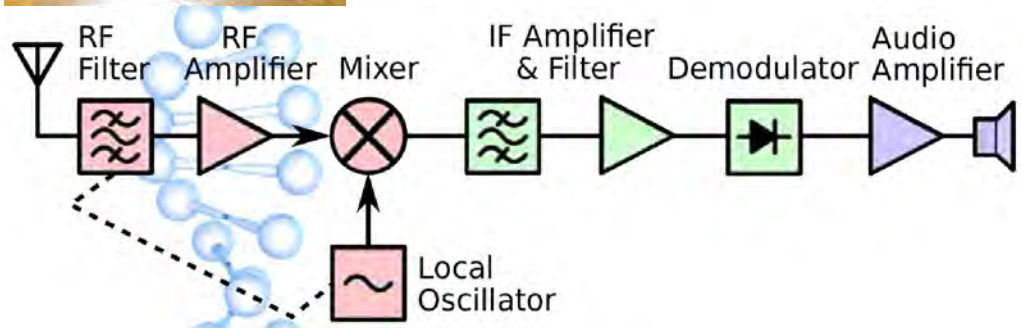

- **Superheterodyne “Superhet” Receiver – Invented by Edwin Armstrong 1922**

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Radio Types and Modulation Formats – 30 min

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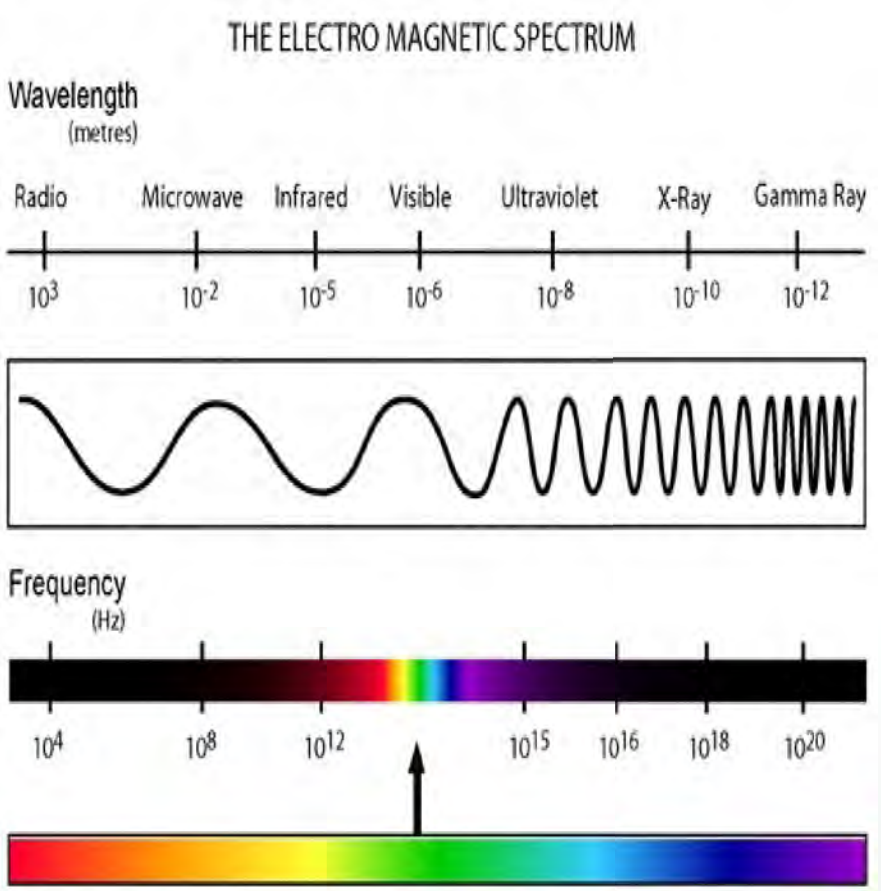

- Radio Spectrum Frequencies Span “DC To Daylight” and Beyond!
- Frequency = 3e8 m s^{-1} / Wavelength
- 1000 meters —› 300 kHz
- 10^{-6} meters (1um Infrared) —› 300 THz
- High Intensity LED + PWM for Optical Communications – BAP64 Photodiode

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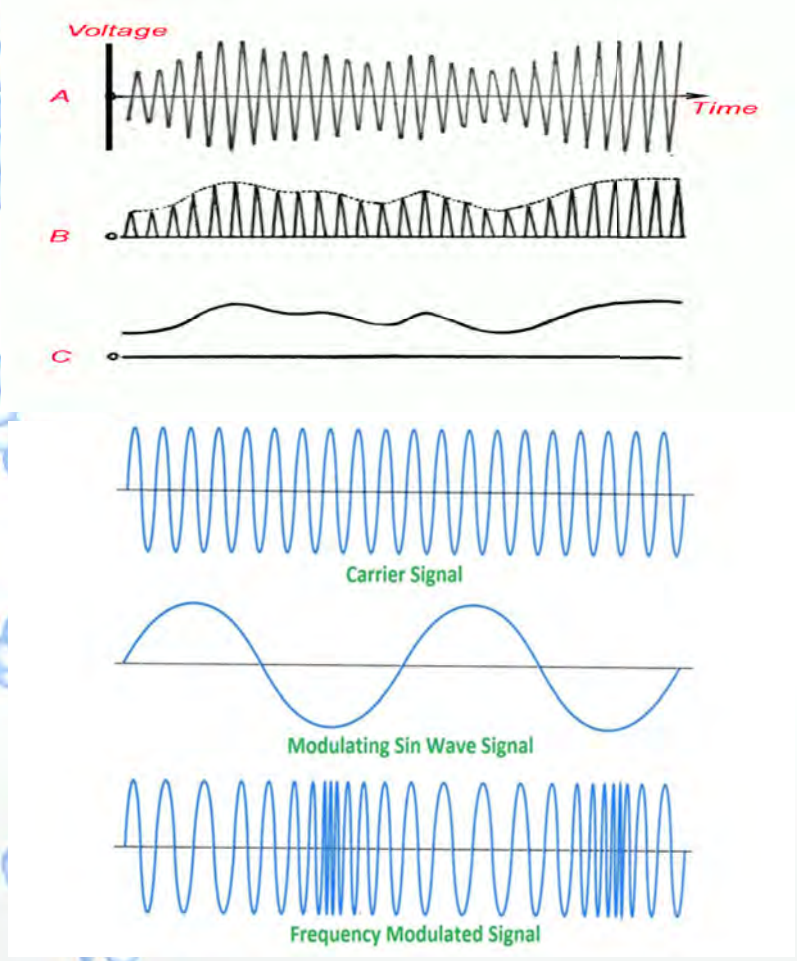

- Amplitude Modulation (AM)
- Earliest Modulation Format (Voice)
- RF Carier Amplitude Varies With Modulating Audio Signal
- Used for Medium Wave & Shortwave
- Typical Modulation Index 30% (MW)
- Very Easy to Demodulate – e.g. TRF!
- High Quality Frequency Modulation (FM)

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- Frequency Modulation (FM) Format Invented By Edwin Howard Armstrong
- FM Patent Lodged 1933
- Edwin Lodged 42 Patents
- Also Responsible for Regenerative, Super-regenerative, Superhetrodyne Receivers – All modern Rx Owe Edwin!

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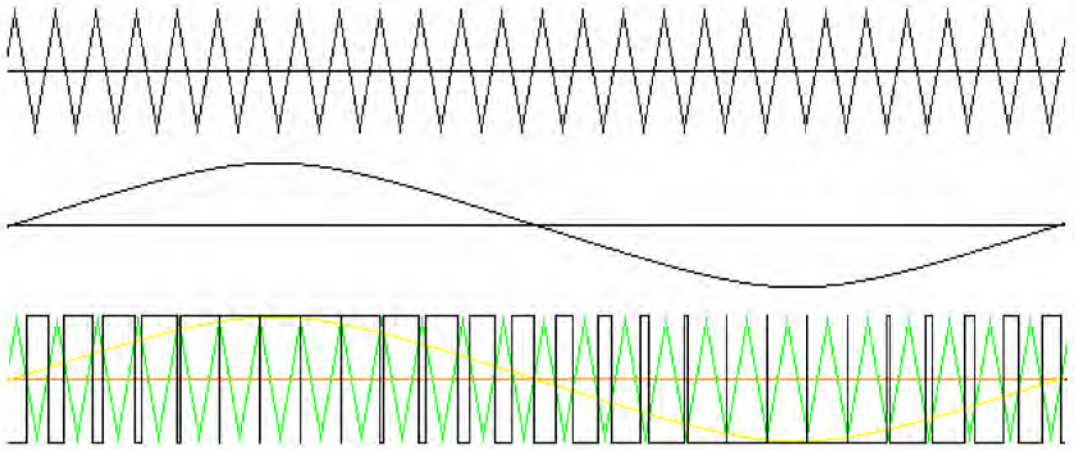
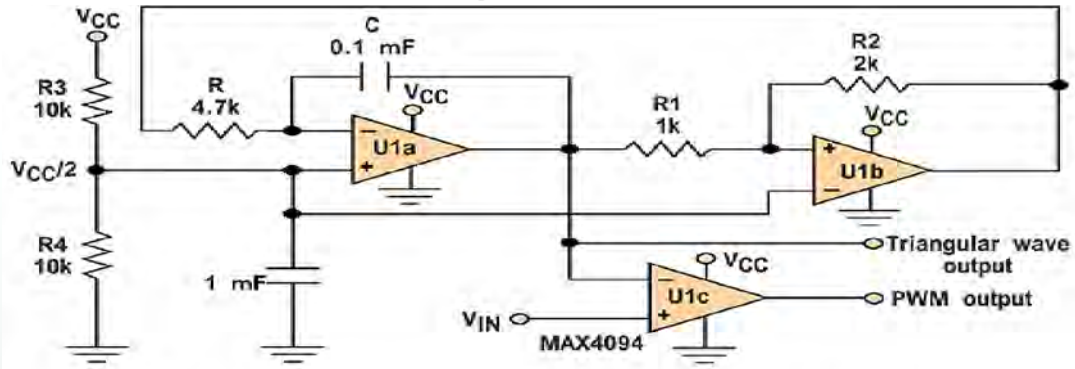


How an Audio Signal is modulated with PWM



1. This three-op-amp circuit produces both a triangular wave and a variable-pulse-width output.

- Pulse Width Modulation (PWM) used For High Quality Audio
- Used For High Efficiency, High Power “Class D” Audio Amplifiers (η close to 100%)
- Extremely Easy to Generate
- Also Easy to Demodulate (LPF)

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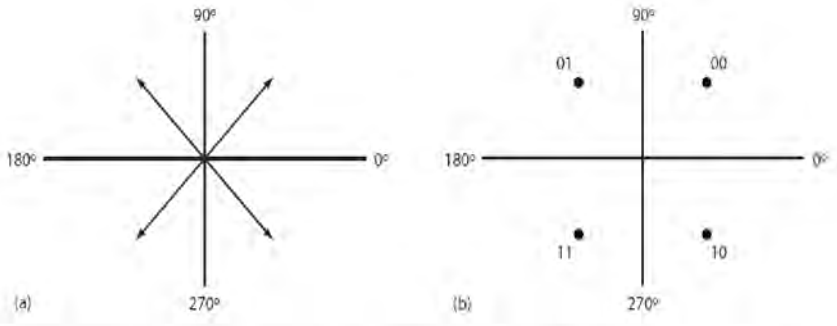
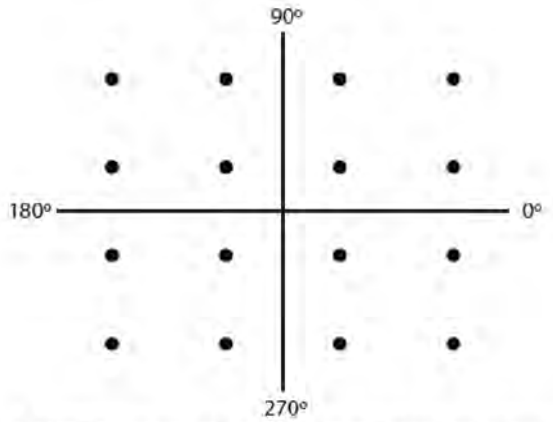


3. Modulation can be represented without time domain waveforms. For example, QPSK can be represented with a phasor diagram (a) or a constellation diagram (b), both of which indicate phase and amplitude magnitudes.



4. 16QAM uses a mix of amplitudes and phases to achieve 4 bits/Hz. In this example, there are three amplitudes and 12 phase shifts.

- **Digital Modulation – Quadrature Phase Shift Keying (QPSK)**
- **Motivation – Improved "Spectral Efficiency" – "2 Bits per Hz"**
- **Suitable for Static Channels**
- **Example 16-QAM – 4 Bits / Hz**
- **Popular IQ Signal Reresentation**

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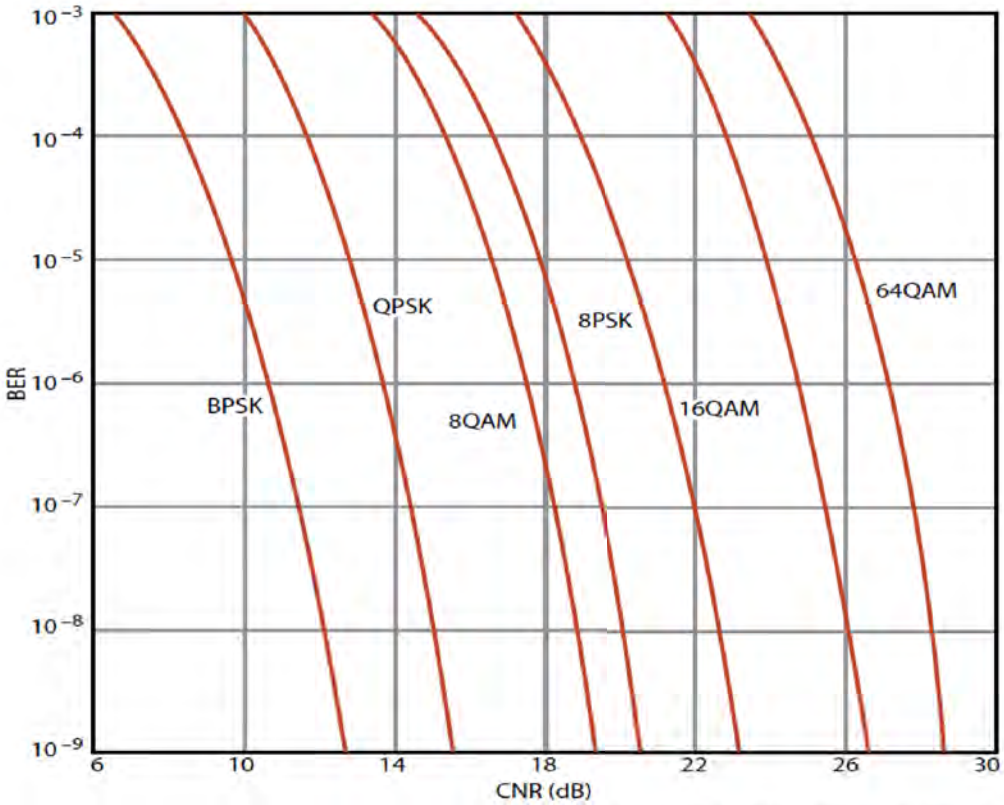

7. This is a comparison of several popular modulation methods and their spectral efficiency expressed in terms of BER versus CNR. Note that for a given BER, a greater CNR is needed for the higher QAM levels.

- Comparison of Digital Formats
- Higher Order QAM Needs Higher Carrier to Noise (CNR) For a Given Bit Error Rate (BER)
- 64-QAM Sometimes Used For Microwave Point-Point Links
- ETS-300-633, 2.65 GHz

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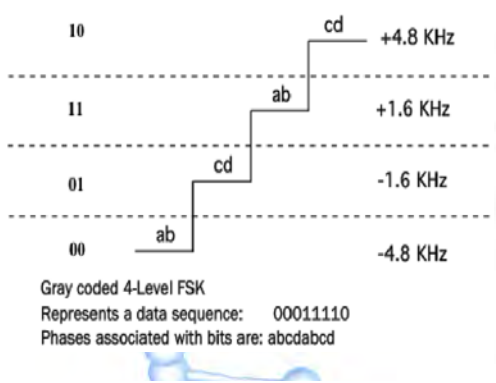
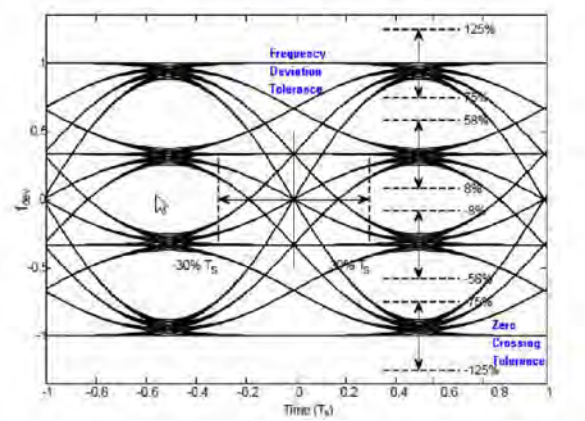
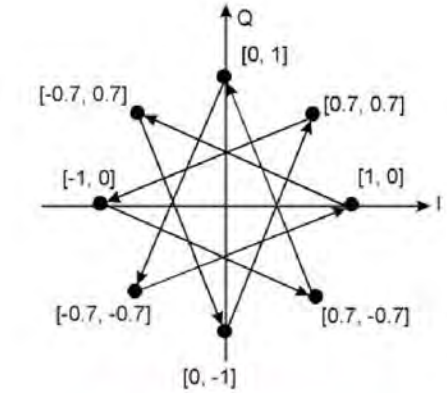
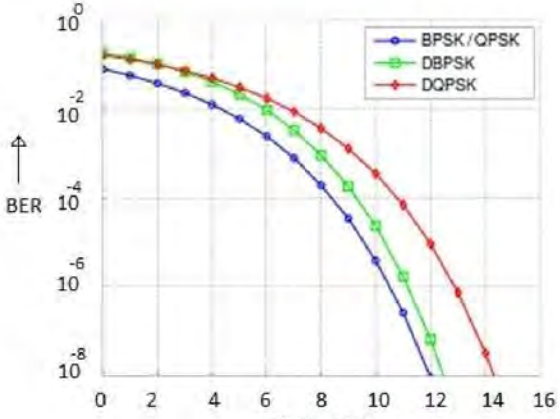






Pi/4 shifted DQPSK Constellation (Unfiltered)



BER Curve

- Although Spectrally Efficient, QAM is Unsuitable for Mobile Evironments – IQ Rotation!
- Solution – Use Differential Encoding – M-FSK, DQPSK
- 4-FSK Popular – 2 Bits/Hz
- DQPSK used For TETRA (Europe)

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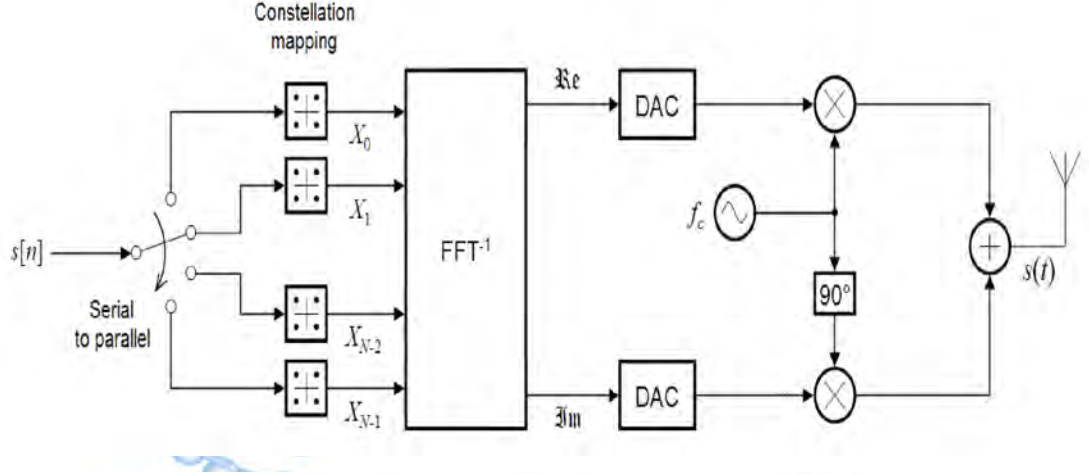

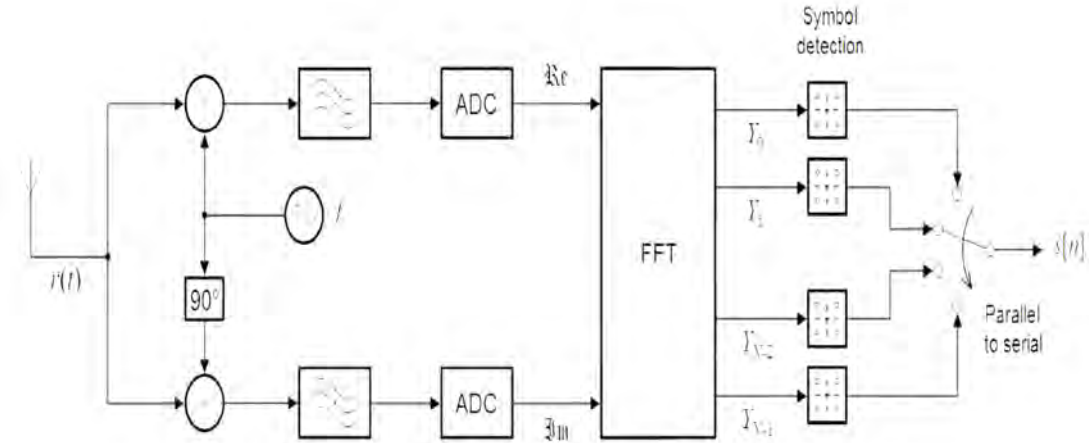

- Orthogonal Frequency Division Multiplex Modulation (OFDM)
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- Lee De Forest's 1904 “Audion”

  radio wave detector Triode Valve

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