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Assignment 1: Radio Frequency

Radio waves (also known as Radio Frequency waves, or RF waves) are the essence of all wireless telecommunication. Broadcasting services such as AM and FM radio, television and most recently technologies such as cell phones, WiFi and Bluetooth all rely upon radio waves to function. In its simplest terms, a radio wave is a form of electromagnetic energy which carries information from a transmitter of one device to a receiver of another. The radio wave is made up of two components; electric and magnetic. The electric wave and magnetic wave oscillate in a perpendicular motion to one another, forming a series of repeating peaks and troths that is unique to the particular wave being transmitted. The distance of one cycle before it is repeated is known as the *wavelength.* The amount of times this wavelength repeats itself in a second determines its *frequency*.[1] Since radio waves always travel at the speed of light (299,792,458 m.s), a wavelength can be determined by dividing the speed of light by its frequency. For radio communication, the signal which contains the information (whether it be an audio signal or video signal) is provided to a transmitter (a device which is often combined with a receiver, referred to as a transceiver). The transmitter combines this signal with a radio wave, which is known as a *carrier signal.* This process is known as *modulation.* The modulated signal containing the information is fed to an antenna, which emits the signal as a radio wave. The structure and effectiveness of an antenna is meant to directly correspond to the wavelength of the signal. An antenna is able to emit and receive radio signals, feeding them back into a receiver (or

[1] "What Are Radio Waves?" NASA. October 19, 2012. Accessed October 15, 2018. https://science.nasa.gov/ems/05_radiowaves.

transceiver) which de-modulates the signal and allows for the information to be readable to human ears.[2]

Transmitters can combine the information with a carrier signal in a few different ways depending on their type. Amplitude modulation (AM) expresses the information by a variation in the amplitude (height) of the signal, whereas frequency modulation (FM) expresses the information by varying it's frequency (rate of oscillation). These two methods each carry their own advantages and disadvantages. For radio broadcasting, AM radio is much more susceptible to interference since it often manifests itself in amplitude spikes. Also, due to it's properties AM radio is not able to occupy as much bandwidth as FM radio. Therefore, FM radio is able to broadcast much higher fidelity sound, making it the clearer choice for music broadcasts. AM and FM radio waves also travel, or "propagate", in different ways.[3] Radio waves with lower frequency and longer wavelengths (such as AM Radio) are able to travel much longer distances. Due to diffraction, lower frequency waves can contort themselves to the contours of the earth and overcome obstacles such as hills and mountains. This is known as *ground-wave propagation*. Higher frequency waves such as FM radio, are limited to travel on a straight line, along the visible horizon, and are often unable to penetrate obstacles. This is known as *line-of-sight propagation*. A variety of different techniques are uses to overcome such limitations and attain a wider broadcast range. This includes the use of multiple directional antennas, "knife-edge" diffraction (the use of an intentional obstacle to bend the signal towards a certain direction) or tropospheric scattering (refracting the signal to reach a broader surface area).[4] Analog television broadcasting uses what is known as *vestigial sideband modulation*, a form of

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[2] "Radio Waves." YouTube. November 3, 2012. https://www.youtube.com/watch?v=sRX2EY5Ubto. (YouTube video explaining Radio Waves)

[3] Wikipedia contributors, "Radio propagation," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Radio_propagation&oldid=863233742 (accessed October 15, 2018).

[4] Wikipedia contributors, "Tropospheric scatter," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Tropospheric_scatter&oldid=851048806 (accessed October 15, 2018).

amplitude modulation in which one sideband is removed, allowing for the bandwidth to be reduced.[5] However, the audio is transmitted on a separate FM radio signal. Digital television, uses *orthogonal frequency-division multiplexing,* a form of frequency modulation which encodes a digital signal onto a wave. Purely analog television sets require a separate digital to analog converter in order to play digital television broadcasts.

The concept of electromagnetic energy was first theorized by James Clerk Maxwell, in his 1873 publication, A Treatise on Electricity and Sound. In 1888, Heinrich Rudolf Hertz successfully proved Maxwell's theory in an experiment in which he was able to transmit airborne electromagnetic waves. Hertz built a make-shift transmitter which used a high-voltage spark to emit radio waves from one conductor to another. This was known as a *spark-gap* transmitter. In 1895, Guglielmo Marconi used the same technology to develop the first ever commercially available radio communications system. Spark-gap transmitters were not able to transmit audio, therefore were mainly used for telegraphy. However, in the early 1920's these transmitters were replaced by *vacuum tube* transmitters, which where able to create continuous waves that could be modulated to transmit audio by way of amplitude modulation. This was able to give rise to the advent of AM radio broadcasting. In 1933, Edwin Armstrong developed frequency modulation which gave way to FM radio broadcasting in 1937.[6] To prevent interference between broadcasts, the radio spectrum was invented, which allocated certain frequencies (between 3 Hz and 3000 GHz) to be used for specific purposes.[7] This was instituted by the International

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[5] Wikipedia contributors, "Broadcast television systems," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Broadcast_television_systems&oldid=864109773 (accessed October 15, 2018).

[6] Wikipedia contributors, "Transmitter," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Transmitter&oldid=858109835 (accessed October 15, 2018).

[7] ITU Radio Regulations – Article 1, Definitions of Radio Services, Article 1.2 Administration: Any governmental department or service responsible for discharging the obligations undertaken in the Constitution of the International Telecommunication Union, in the Convention of the International Telecommunication Union and in the Administrative Regulations (CS 1002)

Telecommunication Union (ITU) and is strictly enforced by law.[8] The first public television broadcast occurred in 1927, however the medium did not begin to catch weight until the late 1930's and continued to grow in popularity after World War II. Later developments include the advent of cable television, which involved the use of coaxial cables or light pulses through fiber optic cables to transmit the RF signals.

RF waves play a notable role in the field video preservation, specifically in the digitization of analog video tapes. Certain analog video devices such as VHS, 1/2" open reel, and 3/4" U-matic playback equipment uses an RF output. This was, at a point in time, a very common way for information to be fed from a video deck into a monitor. The RF signal is fed through a coaxial cable. Certain decks would use a modulator which would allow the video to be viewed from a specific channel (i.e channel 3). However, the RF connection is one the lowest quality methods for viewing video and should only be used if there is no other possible input. Component, S-Video, and Composite connections are much more reliable connections and should be used when making copies or digitizing tapes.[9] However, the RF signal can be fed into a waveform monitor, side-stepping the demodulation process that exists in regular TV monitors. This provides a visualization of the amplitude and frequency of the signal, which can be very useful for real-time metric when doing quality control during a digitization.[10] It can asl be helpful for determining the source of a particular issue.

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[8] "Electromagnetic Spectrum." NASA. September 5, 2018. Accessed October 15, 2018. https://lambda.gsfc.nasa.gov/product/suborbit/POLAR/cmb.physics.wisc.edu/tutorial/spectrum.html.

[9] "Analog Video Connections Which Should I Use and Why?" Accessed October 15, 2018. http://www.scenesavers.com/grfx/analogvideoconnections.pdf.

[10] Piil, Erik. "RF, A Scope for Video Preservation." Erikpill.com. July 14, 2018. Accessed October 15, 2018. http://erikpiil.com/2014/07/14/rf-a-scope-for-video-preservation.html.