Broadcasting Towers Operation

WEEK 5 – Transmitters and Receivers in general

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Objectives

At the end of the topic students will be able to:

1. Explain the general concept of transmitters.
2. Explain the general concept of receivers.
3. Characterize transmitters and receivers.

Recap

- The identification and selection of tools is essential for proper usage while performing various tasks on a broadcasting towers or while preparing equipment to be installed on the site.
- Identification and selection of equipment is also of good emphasis to know which equipment that best suit the specific activity on or for a broadcasting tower.
- Review of fundamental principles for both electronics and telecommunication has brought back important concepts required in broadcasting towers.
- It is our duty to use the knowledge and apply the skills acquired from the above principles and concepts to perform all the required operation on a broadcasting tower.

5.0 General introduction

- Transmitters: devices that convert information into signals for transmission or simply devices that send signals.
- Receivers: devices that capture signals and convert them back into usable information. Or simply devices that receive signals.
- Transmitters and receivers are classified as analogue digital, and specialized types.
- Analogue transmitters are characterized by continuous signals, varying amplitude and angle (frequency and phase) like AM and FM.
- Digital transmitters are characterized by discrete signals, binary encoding like Wi-Fi transmitters, digital TV transmitters.
- Specialized transmitters are characterized by the special type of signal and application they work with like Infrared transmitters, optical transmitters.

5.0 General introduction cont’d

- Analogue receivers are characterized by processing continuous signals, demodulation techniques like AM and FM radios.
- Digital receivers are characterized by decoding digital signals, error detection and correction like digital TV receivers, smartphones.
- Specialized receivers are characterized by the special type of signal and application they work with like Infrared receivers, satellite receivers.

5.1 Transmitters

- Transmitters are essential components in communication systems, converting electrical signals into radio waves for transmission over distances. They are used in various applications, including radio, television, and wireless communication.
- They take input signal (analogue or digital) and convert it into the format suitable for transmission. It requires Modulation to ensure long distances information transfer, Oscillation to generate high frequency carrier wave for transmission through air, Amplification to increase the power of the signal to be transmitted ensuring it can travel the required distance without significant loss and Transmission handing the signal to the antenna, which radiates electromagnetic waves. (Wireless Communication Electronics: Introduction to RF Circuits and DesignTechniques, Robert Sobot, Springer, 2021.)

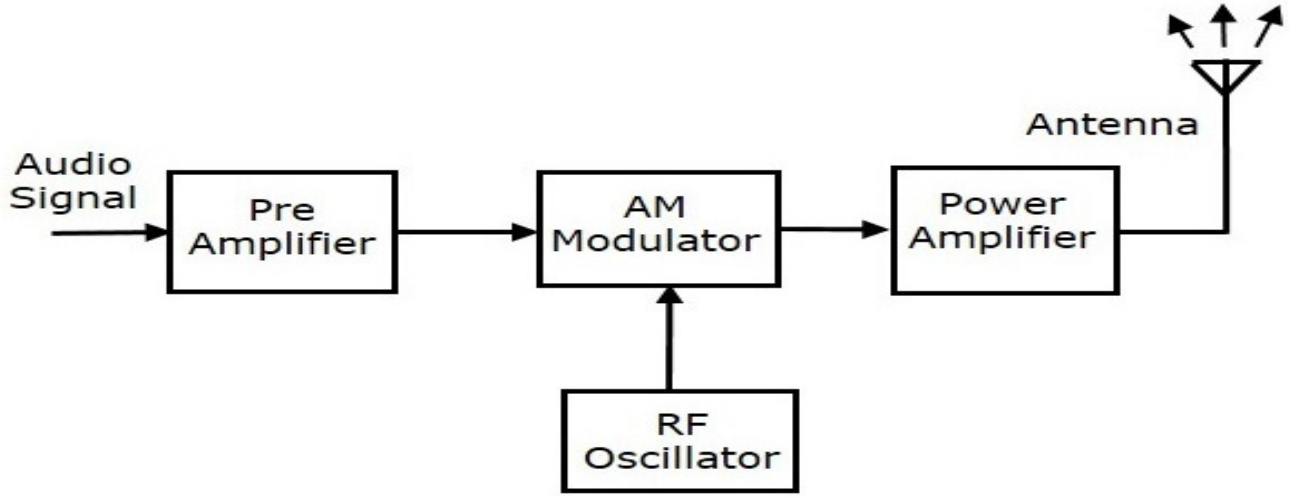
5.1 Transmitters cont'd

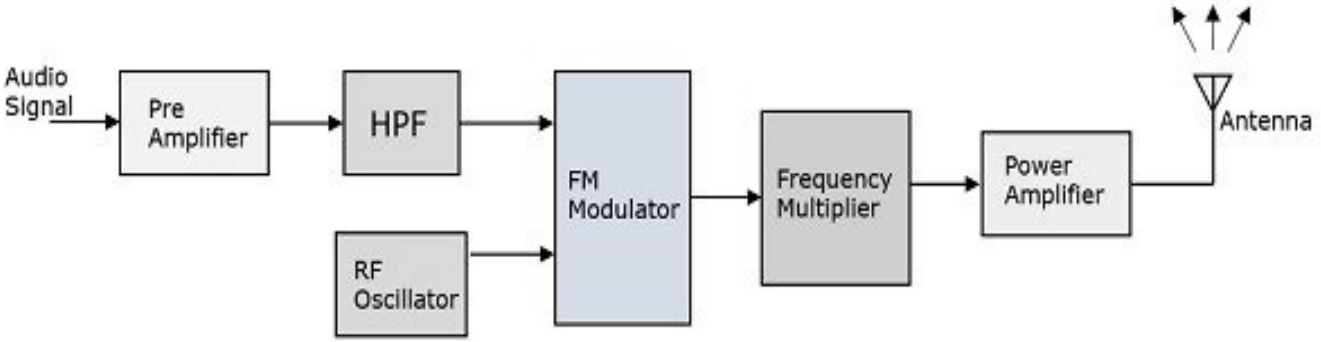
- AM transmitter takes audio signal as an input and delivers amplitude modulated wave to the antenna as an output to be transmitted.
- Audio signal from microphone or the source signal is sent to the pre-amplifier to be boosted at a higher level as the modulating signal, the RF oscillator generates the carrier signal to perform the modulation process by using a modulator or a mixer (in this case it is AM modulator), power amplifier is used to increase the power levels of AM wave which is finally passed to the antenna for transmission.
- FM transmitter takes the audio signal as an input and delivers FM wave to the antenna as an output to be transmitted.
- An FM transmitter functions by first capturing the audio signal from a microphone and sending it to a pre-amplifier, which boosts the signal's level.

5.1 Transmitters cont’d

- The amplified signal then passes through a high-pass filter, which acts as a pre-emphasis network to reduce noise and improve the signal-to-noise ratio.
- The cleaned signal is then fed into the FM modulator circuit. Simultaneously, an oscillator circuit generates a high-frequency carrier wave, which is combined with the modulating audio signal in the modulator.
- To achieve the desired transmission frequency, the signal undergoes several stages of frequency multiplication. Since the signal’s power is still insufficient for transmission, it is further amplified using an RF power amplifier.
- The final FM modulated signal, now at a higher power level, is sent to the antenna, where it is transmitted as radio waves. This process ensures that the audio signal is effectively broadcast over a specified frequency range.

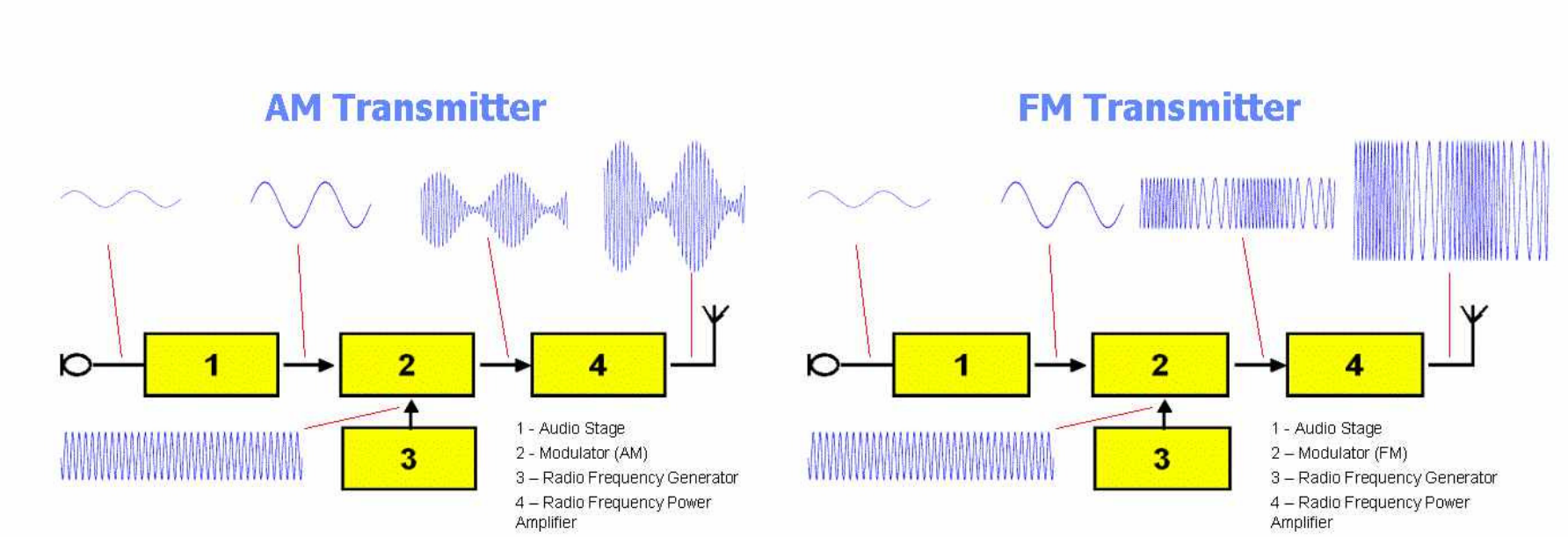
5.1 Transmitters cont'd





(https://www.tutorialspoint.com/analog_communication/analog_communication_transmitters.htm)

5.1 Transmitters cont'd



(http://www.g4prs.org.uk/Foundation%20Course%20Material/Transmitter_Block_Diagram.htm)

5.1 Transmitters cont'd

- An amplifier is an electronic device that increases the voltage, current, or power of a signal.
- During pre-amplification, low level signals are amplified to line level or the standard operating level of your recording gear.
- Three basic types of preamplifiers are the current-sensitive preamplifier, the parasitic-capacitance preamplifier, and the charge-sensitive preamplifier. They adjust the signal level and the signal routing to suit different conditions.
- A radio-frequency power amplifier (RF power amplifier) is a type of electronic amplifier that converts a low-power RF signal into a higher power signal.
- RF power amplifiers are used in the final stage of a radio transmitter, their output driving the antenna.

5.1 Transmitters cont'd

Pre-amplifier	Amplifier
Electronic device, used to prepare audio signal for amplification or recording. Also, preamp	Electronic device, used to provide the power supply to your headphones or speakers. Also, amp.
Found always in integrated amps or AV receivers. Its cost is low.	Found in TV transmitters and receivers, radios, microcomputers, high-fidelity stereo equipment, digital equipment, and musical instruments. Its cost from low to moderate
Has various inputs and single output and a fixed gain.	Has a single input & various outputs and does not have a set gain.
Contains fixed input impedance.	Its input impedance is fixed or adjustable.
It doesn't have tone controls.	Has tone controls like bass and treble.
Has two audio channels.	Has up to seven channels.

(https://www.elprocus.com/preamplifier/)

5.1 Transmitters cont'd

- The image shown on the right is a cellular amplifier well suited for LTE, Cellular, WCDMA, GSM, PCS and UMTS systems, designed in combination with various technologies, symmetrical and asymmetrical Doherty configurations to achieve high efficiency and feed-forward, analogue pre-distortion and other linearization techniques to achieve high linearity.
- They are applied in CDMA, WDCDMA, LTE or 5G systems, Remote Radio Head (RRH) units, Repeaters, Distributed Antenna Systems (DAS).

(https://inspower.co.kr/cellular-power-amplifiers/)

5.1 Transmitters cont'd

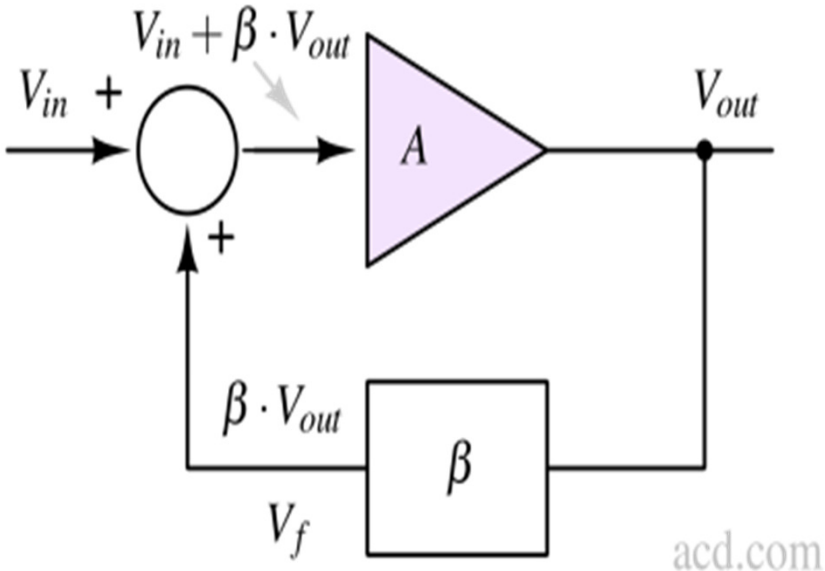
- An oscillator is a circuit that creates a continuous, alternating waveform from a DC source without any external input. It converts a one-way current into an alternating waveform at a frequency determined by its components.
- Oscillators maintain their output by converting electrical energy into electromagnetic energy and back, using components like capacitors and inductors.
- There are many types of oscillators but can broadly be classified into two main categories; Harmonic Oscillators or known as Linear Oscillators and Relaxation Oscillators.
- In a harmonic oscillator, the energy flow is always from the active components to the passive components and the frequency of oscillations is decided by the feedback path.

5.1 Transmitters cont'd

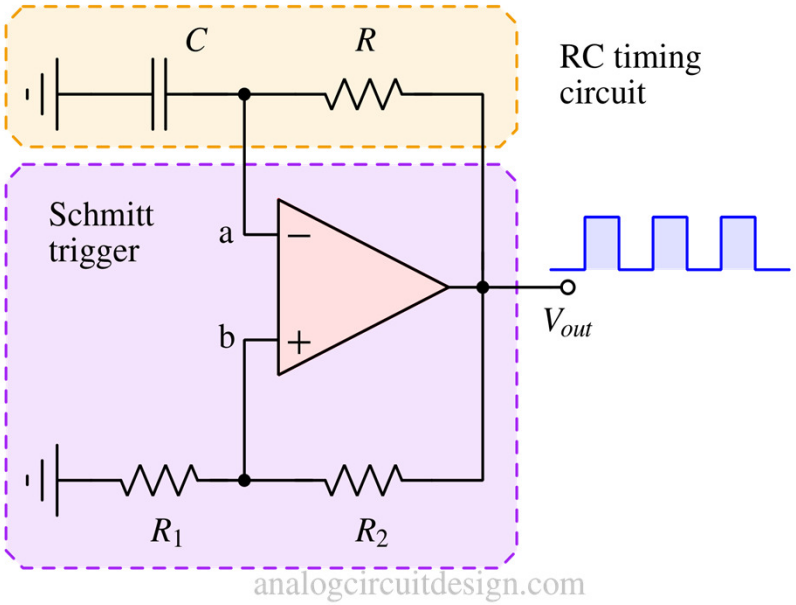
- In a relaxation oscillator, the energy is exchanged between the active and the passive components and the frequency of oscillations is determined by the charging and discharging time-constants involved in the process.
- Further, harmonic oscillators produce low-distorted sine-wave outputs while the relaxation oscillators generate non-sinusoidal (saw-tooth, triangular or square) wave-forms.
- Oscillators are crucial in technology for generating precise frequencies needed in devices like watches, radios, and computers.

(https://www.electrical4u.com/what-is-an-oscillator/)

5.1 Transmitters cont'd



Feedback system for harmonic oscillators



Relaxation oscillator

(https://analogcircuitdesign.com/introduction-to-electronic-oscillators/)

5.1 Transmitters cont'd

- Transmitters are usually classified into analogue and digital depending on the signal they transmit. An analogue transmitter measures in real time, has a measurement accuracy approximately 1 percent and is very responsive.
- A digital transmitter is microprocessor-based and measures in sampled time. Its measurement is digitized, it is generally not as responsive as analogue transmitter, it can communicate digitally with other devices and can be easily re-ranged. A digital transmitter has a measurement accuracy of approximately 0.1 percent.

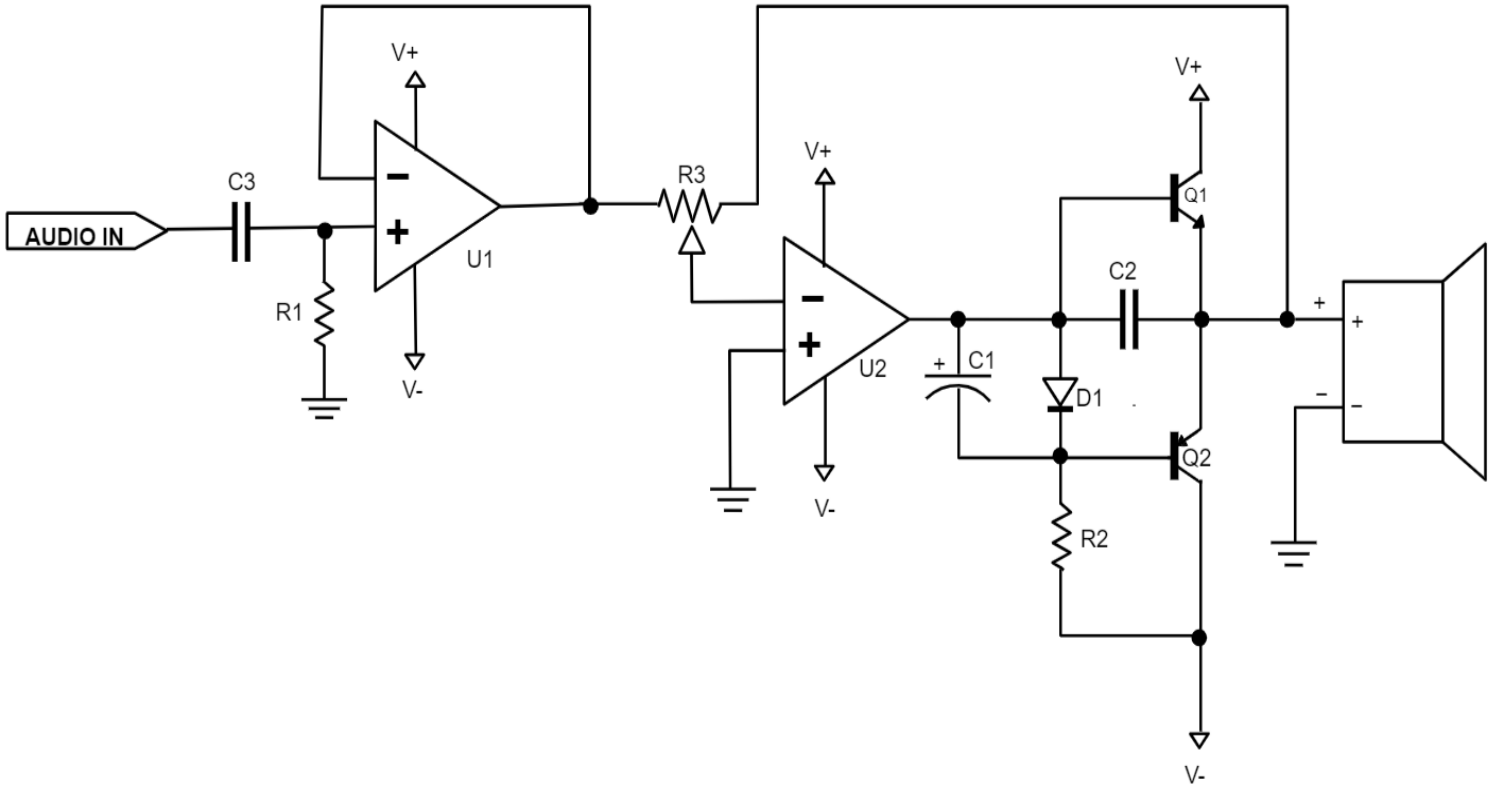
(https://blog.isa.org/autoquiz-difference-industrial-digital-analog-transmitter)

- Analogue types use electronic components in linear circuits such as OPAMPs while microprocessors, ADC converters, and DAC are used.

5.1 Transmitters cont'd

- Analogue types use electronic components in linear circuits such as Op-amps while microprocessors, ADC converters, and DAC are used.
- Most of fundamental electronic components (resistors, capacitors, inductors, diodes, transistors, and op amps are all inherently analogue components and circuits built with a combination of these components are analogue circuits which implement analogue devices such as transmitters.
- On the other hand, digital circuits are built by components such as logic gates or more complex digital ICs like microprocessors and microcontrollers. Such ICs are represented by rectangles with pins extending from them and when combined, they implement digital devices such digital transmitters.
- They require addition proces such as ADC and DAC which related analogue and digital signals on either terminals (Transmitting and receiving).

5.1 Transmitters cont'd



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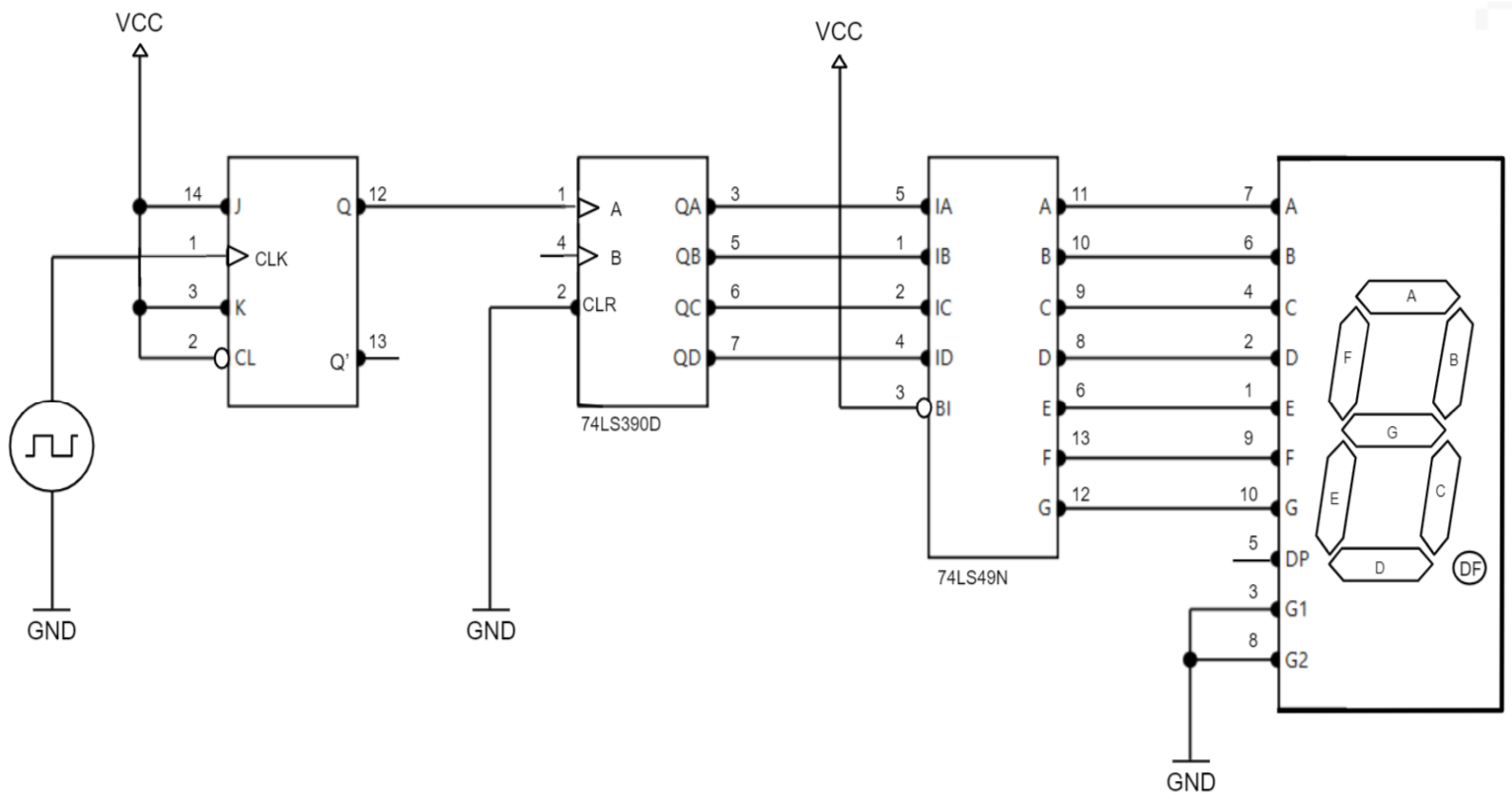
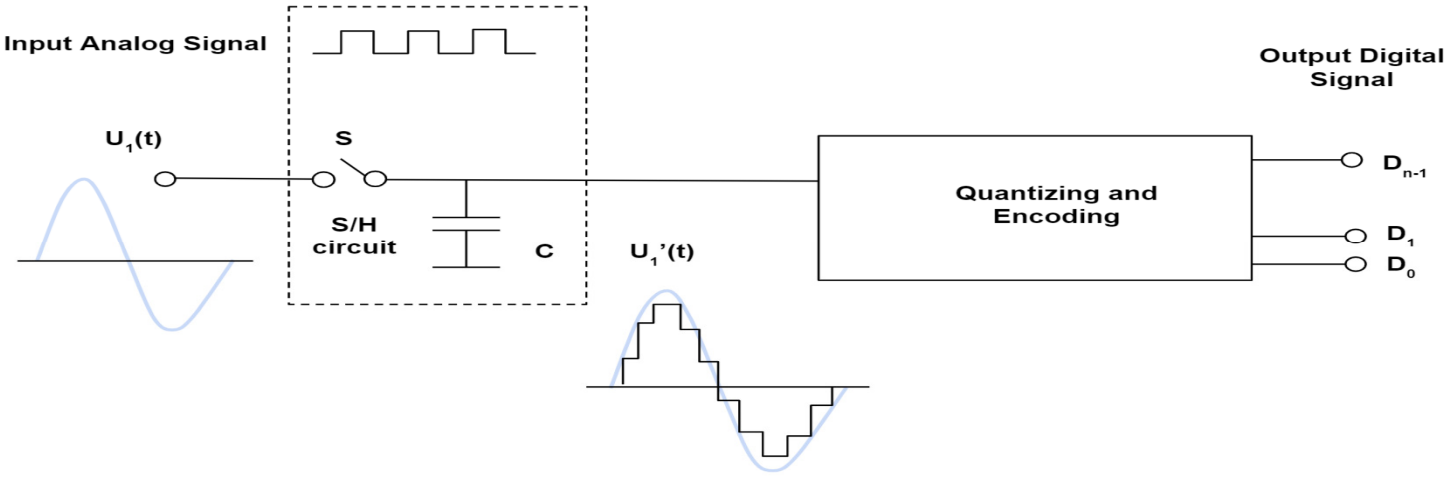
5.1 Transmitters cont'd

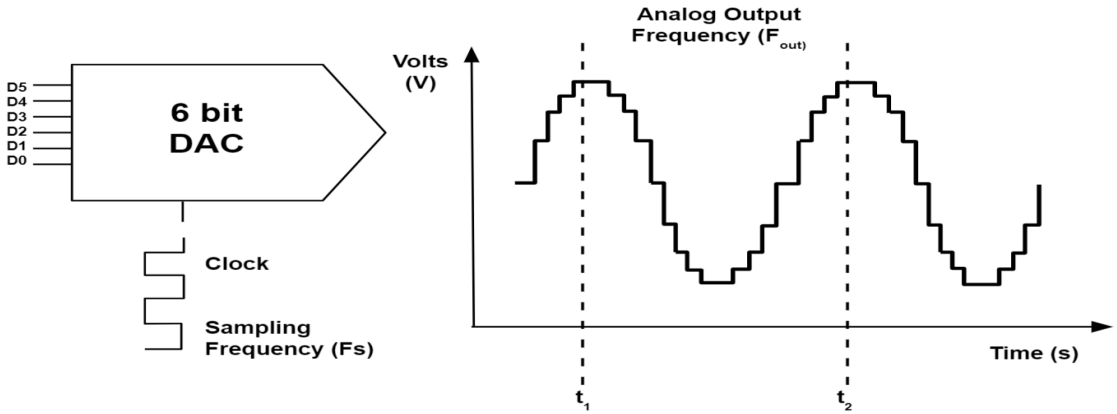


(https://www.monolithicpower.com/en/learning/resources/analog-vs-digital-signal?srsltid=AfmBOoqaacbAc0NhoX8T9Da710780-uRq_rbfVpT5hqoIeFDuw-u4RtV)

5.1 Transmitters cont'd



Time	D5	D4	D3	D2	D1	D0
1/Fs	0	1	1	1	1	1
2/Fs	1	0	1	0	1	0
3/Fs	1	1	1	0	0	0
.	.	.	.	.	.	.
.	.	.	.	.	.	.
N-2/Fs	0	1	0	1	0	1
N-1/Fs	0	0	0	1	1	1
N/Fs	1	1	0	1	0	1



(https://www.monolithicpower.com/en/learning/resources/analog-vs-digital-signal?srsltid=AfmBOoqaacbAc0NhoX8T9Da710780-uRq_rbfVpT5hqoIeFDuw-u4RtV)

5.1 Transmitters cont'd

Transmitter	Analog	Digital
Accuracy	0.25% to 1%	0.02% to 0.1%

Feature	Analog	Smart
Range	0-5/30 0-25/150 0-125/750	0-0.83/25"H20 0-8.3/250 0-33.3/1000
Accuracy Linearity Hysteresis	±0.2% span ±0.1% span ±0.5% span	±0.1% span, includes linearity, hysteresis, and repeatability
Stability	±0.2% URL – 6 months	±0.1% URL-12 months

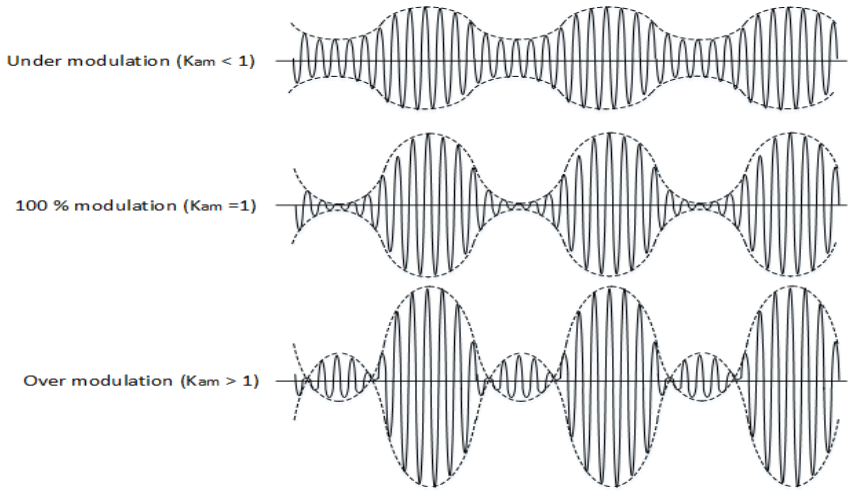
(https://i0.wp.com/instrumentationapplications.com/wp-content/uploads/2022/07/TABLE-ANALOG-DIGITAL-FEATURES.png?w=491&ssl=1)

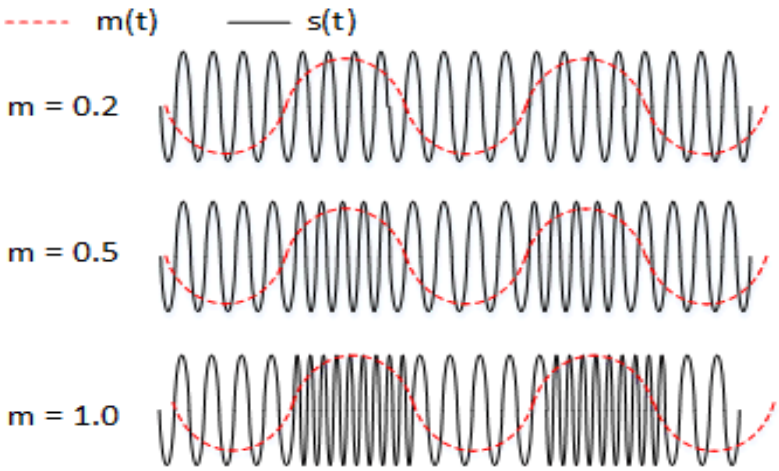
5.1 Transmitters cont'd

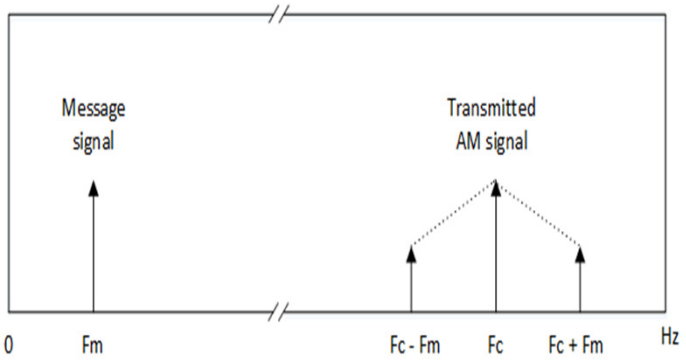
- Modulators are used suitable to the transmitter (analogue or digital) and the signal modulation will follow the principles of the specific modulator such DSB-FC, DSB-SC SSB-SC, FM, PAM, PWM, PCM, QAM, OFDM, etc.
- Analogue modulators work by changing the characteristics of the carrier following the continuous modulating signal (amplitude, frequency and phase) while discrete modulators work intermediately with analogue and digital modulating signal in combination (discrete or digital in either parameter with the other parameter remaining continuous) and lastly digital modulators working on digital modulating signal.
- Basically, we have:

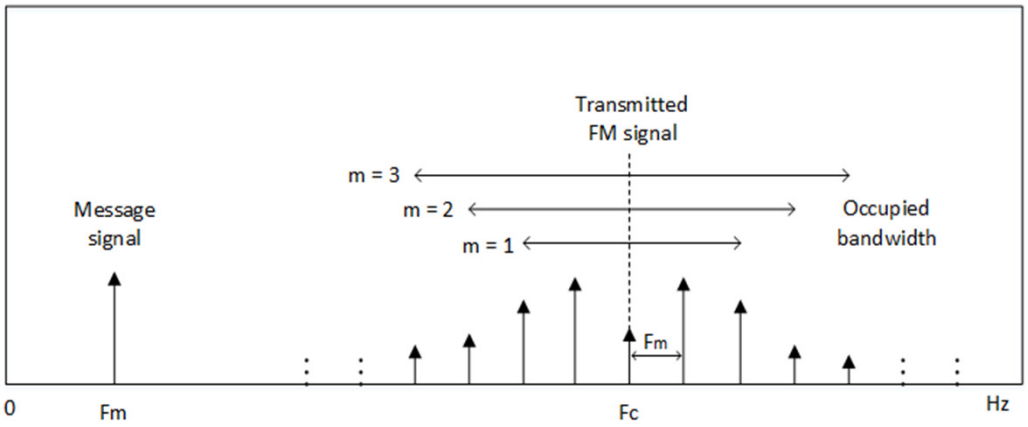
1. AM, FM, PM as analogue modulators
2. PAM, PWM, PPM, PCM, DM for discrete or pulse modulators
3. ASK, FSK, PSK, QAM for digital modulators

5.1 Transmitters cont'd









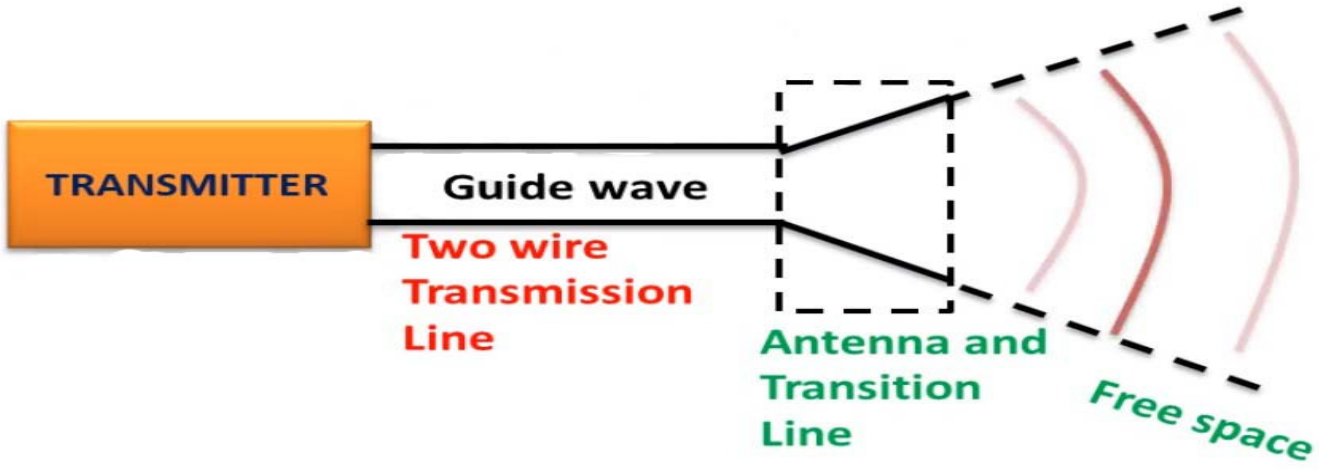
(https://www.cdt21.com/design_guide/analogue-modulation/)

5.1 Transmitters cont'd

- Antenna tuner or impedance matching circuit matches the impedance of the transmitter to that of antenna for the transfer of power to the antenna to be efficient and prevent a condition called standing waves, where power is reflected from the antenna back to the transmitter, wasting power or damage.
- In the final stage of a transmitter, the transmission process involves converting electrical signals into electromagnetic waves to be radiated by an antenna.
- The generated and amplified RF signal is fed into the antenna through a transmission line, which ensures minimal loss of signal strength.
- The antenna (transducer that converts electrical energy into electromagnetic waves that propagate through the air) radiates the RF energy into space, ensuring that the signal reaches the intended receivers. (Antenna Theory: Analysis and Design, Constantine A. Balanis, John Wiley & Sons, 2016.)

5.1 Transmitters cont'd

- The efficiency of this transmission process is influenced by factors such as the antenna's gain, directivity, and impedance matching with the transmitter. Therefore, proper impedance matching is essential to maximize power transfer and minimize reflections that can cause signal loss.



(https://www.electroniclinic.com/antenna-how-antennas-work-and-types-of-antenna/)

5.2 Receivers

- The antenna present at the beginning of the receiver section, receives the modulated wave. First let us discuss the requirements of a receiver.
- Receivers (AM, FM) receives modulated wave and demodulates it by using the envelope detector and Frequency Discrimination method, respectively.
- Important considerations: the receiver should be cost-effective, receives the corresponding modulated waves, be able to tune and amplify the desired station, able to reject the unwanted stations and demodulation must be done to all the station signals, irrespective of the carrier signal frequency.
- For these requirements to be fulfilled, the tuner circuit and the mixer circuit should be very effective following RF mixing phenomena.

(https://www.tutorialspoint.com/analog_communication/analog_communication_receivers.htm)

5.2 Receivers cont'd

- The RF mixing unit develops an Intermediate Frequency (IF) to which any received signal is converted, to process the signal effectively.
- RF Mixer is an important stage in the receiver as two signals of different frequencies are taken and one signal level affects the level of the other signal, to produce the resultant mixed output.
- The AM super heterodyne receiver takes the amplitude modulated wave as an input and produces the original audio signal as an output.
- It is characterized by its selectivity (ability of selecting a particular signal, while rejecting the others) and its sensitivity (the capacity of detecting RF signal and demodulating it, while at the lowest power level).

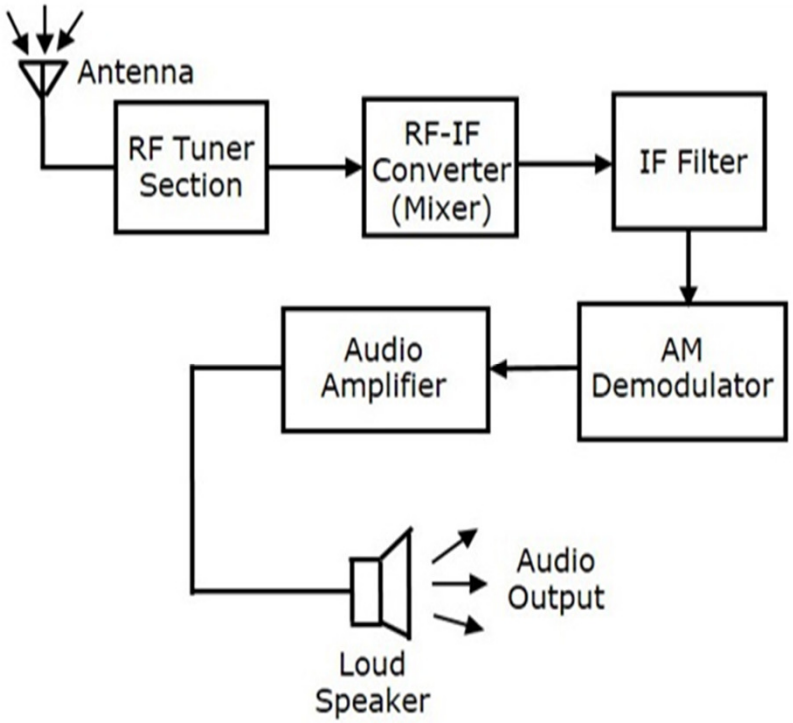
(https://www.tutorialspoint.com/analog_communication/analog_communication_receivers.htm)

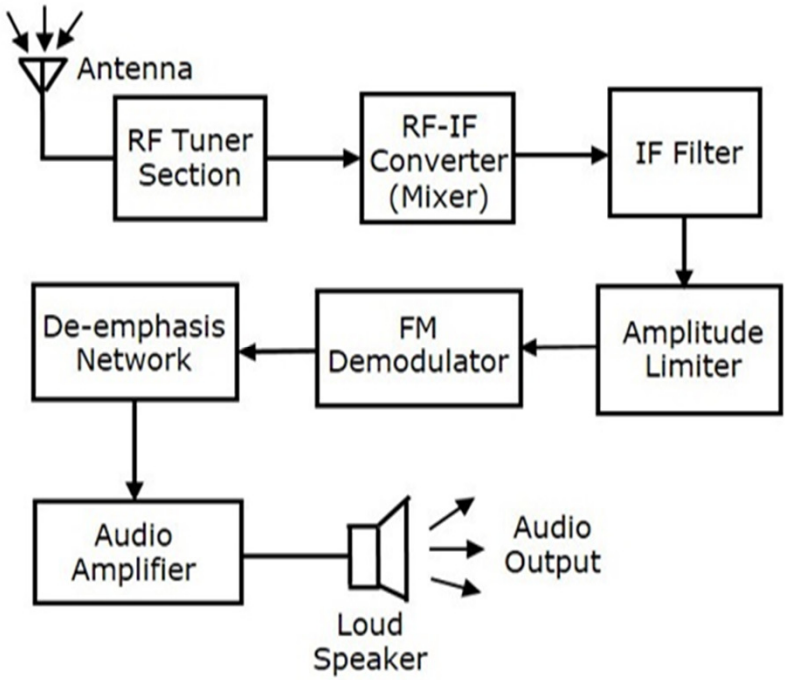
5.2 Receivers cont’d

- FM receiver is like AM receiver except an amplitude limiter and a de-emphasis network added for FM.
- The amplitude limiter ensures the FM wave’s amplitude remains constant by removing noise peaks, maintaining signal stability.
- The de-emphasis network, a low pass filter, reverses the pre-emphasis applied during transmission to improve the signal-to-noise ratio of high-frequency audio signals.
- After demodulation, the signal is amplified by the audio amplifier to increase its power level, ensuring clear audio output from the loudspeaker. This process ensures the original sound signal is accurately recovered and amplified.

(https://www.tutorialspoint.com/analog_communication/analog_communication_receivers.htm)

5.2 Receivers cont'd





(https://www.tutorialspoint.com/analog_communication/analog_communication_receivers.htm)

5.3 TX and RX characteristics

- Targeting performance, efficiency, and reliability of a transmitter in various communication systems. The following characteristics must be ensured.
- Frequency range as a band of frequencies where the transmitter can operate ensuring no interfere with other signals and complying to regulatory standards.
- Power output in watts with signal strength to be high to travel long distances.
- Modulation type: simplicity, cost-effective but also noise immunity and sound quality to be overall key.
- Efficiency as effectiveness of the transmitter to generate radio waves with less generation and less power consumption for better continuous operation.
- Frequency stability for maintaining a consistent frequency over time and avoid signal drift that can lead to signal loss or interference with other transmissions.

5.3 TX and RX characteristics

- Automatic Gain Control (AGC) maintains consistent signal strength by adjusting the gain automatically to stabilize the output varying signal levels.
- Impedance matching between the transmitter's output impedance and antenna input impedance to maximize power transfer and minimize signal reflections.
- Bandwidth as range of frequencies a transmitter can effectively use to transmit data wider bandwidth helps in high data rates and best quality of transmission.
- Harmonic suppression to minimize the generation of harmonics as unwanted frequencies that can cause interference with other signals.
- Signal-to-Noise Ratio (SNR) which is the ratio of the desired signal to the background noise. High SNR indicates clearer and more reliable transmission. (HF Radio Systems and Circuits, William E. Sabin and Edgar O. Schoenike, IET (Institution of Engineering and Technology), 1998.)

5.3 TX and RX characteristics cont'd

- Sensitivity for detecting weak signals where high sensitivity allows to pick up faint signals, crucial for long-distance communication.
- Selectivity of the desired signal from a range of frequencies while rejecting others ensuring isolation of the intended signal from nearby frequencies and reduce interference.
- Noise figure as the measure of the noise added by the receiver itself to test better performance, as it means the receiver adds less noise to the signal, resulting in clearer reception.
- Dynamic range as that range between the smallest and largest signals the receiver can handle without distortion. A wide dynamic range allows the receiver to process both weak and strong signals effectively.
- Frequency stability for maintaining a consistent frequency over time to prevent signal drift and ensure reliable reception.

5.3 TX and RX characteristics cont'd

- Bandwidth allow receiver to handle more information and convey high data rates.
- Demodulation capability for extracting the original information from modulated carrier wave. Different receivers are designed to demodulate various types of modulation, such as AM, FM, or digital modulation schemes.
- Image rejection as ability to reject unwanted mirror frequencies that can interfere with the desired signal. Good image rejection improves the clarity and quality of the received signal.
- Intermodulation distortion to handle multiple signals without generation of false frequencies. When low, receiver can process multiple signals without interference.
- Automatic Gain Control (AGC) to adjusts the receiver's gain automatically for maintaining a consistent output level and stable reception of varying signal. (Communication Receivers: Principles and Design, Ulrich L. Rohde, Jerry C. Whitaker, and T.T.N. Bucher, McGraw-Hill Education, 2001.)

Thank you for your good attention

Q&A

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