Communication Circuits Design

Academic year 2018/2019 – Semester 2 – Week 2

Lecture 1.1: Introduction

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Personal Introduction

- Dr Wasim Ahmad
- Courses Taught in the past
  - Introductory Programming (Year-1)
  - Microelectronic Systems (Year-1)
  - Team Design Project and Skills (Year-3)
- Course currently teaching
  - Communication Circuit Design (Year-3)
  - Real-Time Computing Systems & Architecture (Year-4)
- Research area
  - Signal Processing and Machine Learning
  - Assistive technologies (Intelligent Systems)
  - Emotion Recognition from Speech
  - Gesture Recognition
  - SON
- Short project, Final Year Project or PhD

Introduction to the Course

Course Aims

- The aims of this course is to provide students with an appreciation and understanding of the requirements, specification, and design of circuits used in communications systems.

Intended Learning Outcomes

- Describe the key blocks in a communications system and explain the impact of the channel on system performance.
- Describe the operational characteristics of common semiconductor devices used in communications and apply their simplified standard models to circuit analyses and simulation.
- Analyse circuits used for modulation and demodulation in typical communication systems.
- Describe the operation of a phase-locked loop (PLL) and its applications in communication systems.
- Assess the stability of a circuit as a function of frequency and jitter.
- Analyse and design standard circuits based on transistor amplifiers, integrated circuit blocks, and/or a PLL to meet a given application.

Timetable

	Monday	Tuesday	Wednesday	Thursday	Friday
Session 1-2 **08:30 – 10:05**	Lecture Li Ren B207 (Weeks 2, 5, 9, 12)		Lecture Li Ren B207 (Weeks 2, 5, 9, 12)		Lecture Li Ren B207 (Weeks 2, 5, 9, 12)
Session 3-4 **10:20 – 11:55**	Lab Class-1 MB A1-405 (Weeks 2, 5, 9, 12)	Lecture Li Ren B216 (Weeks 2, 5, 9, 12)	Lab Class-4 MB A1-405 (Weeks 2, 5, 9, 12)	Lecture Li Ren B216 (Weeks 2, 5, 9, 12)	
Session 5-6 **14:30 – 16:05**	Lab Class-2 MB A1-405 (Weeks 2, 5, 9, 12)	Lab Class-3 MB A1-405 (Weeks 2, 5, 9, 12)		Office Hours Wasim Ahmad 14:30 – 16:00 MB A1-305	
Session 7-8 **16:20 – 18:55**					Tutorial MB A1-405 (Weeks 2, 5, 9, 12)

Reference Books

- Razvan, RF Microelectronics, 2nd edition
- Beasley and Miller, Modern Electronic Communication, 9th edition
- Sobot, Wireless Communication Electronics (PDF in Glasgow library)
- Analog Integrated Circuits for Communication, 2nd edition (PDF in Glasgow library)

Course Material

- All course material will be available on Moodle (UoG).
  - Syllabus
  - Lecture slides
  - Lab manual and datasheets
  - Tutorial Questions
  - Past exam papers

Course Assessment

- Laboratory & Coursework – 25%
  - Total 4 labs during weeks 2, 5, 9 and 12.

- Written Final Examination – 75 %
  - Final Exam: Closed book exam at the end of the semester (during weeks 17, 18, 19, 20)

Lab Exercises and Marking

- Lab handout will be available on Moodle before each week lab session.
- You will work individually during lab session.
- You are required to complete all the exercises and the questions included in the lab handout before the deadline.
- Submit your completed lab report before the deadline.
- Do not miss the lab.

Final Exam

- All material in the lectures, tutorials, and laboratories work are examinable.
- Aim is to test your understanding not to test your memory of all the details; explain why – don't recite what.
- The final written exam will be consists of **four question** and you have to complete all of them.

Requirements for Grade

- To receive a grade at the end of the course, you must:
  – attend all the labs (total 4 lab sessions),
  – complete and submit all the lab reports by the deadline.
  – attend the final exams.

- If you fail to fulfil any of the above requirement, you will be given “CW”.
- CW (Credit Withheld) means that you have not completed some part of the assessment (exam, laboratory report, etc) but can still do so before the next academic year. Contact the course lecturer if you are in doubt as to what you need to do.

Introduction to Electronic Communication

Objectives

- After completing this lecture, you will be able to:
  - Explain the functions of the three main parts of an electronic communication system.
  - What is noise, how it effect the ewcwivwd signal, and explain the external and inter noise the electronic communication system.
  - Explain gain, attenuation, decibel and signal-to-noise ratio.
  - How to compute gain, attenuation, decibel and signal-to-noise ratio.

Significance of Communication (1)

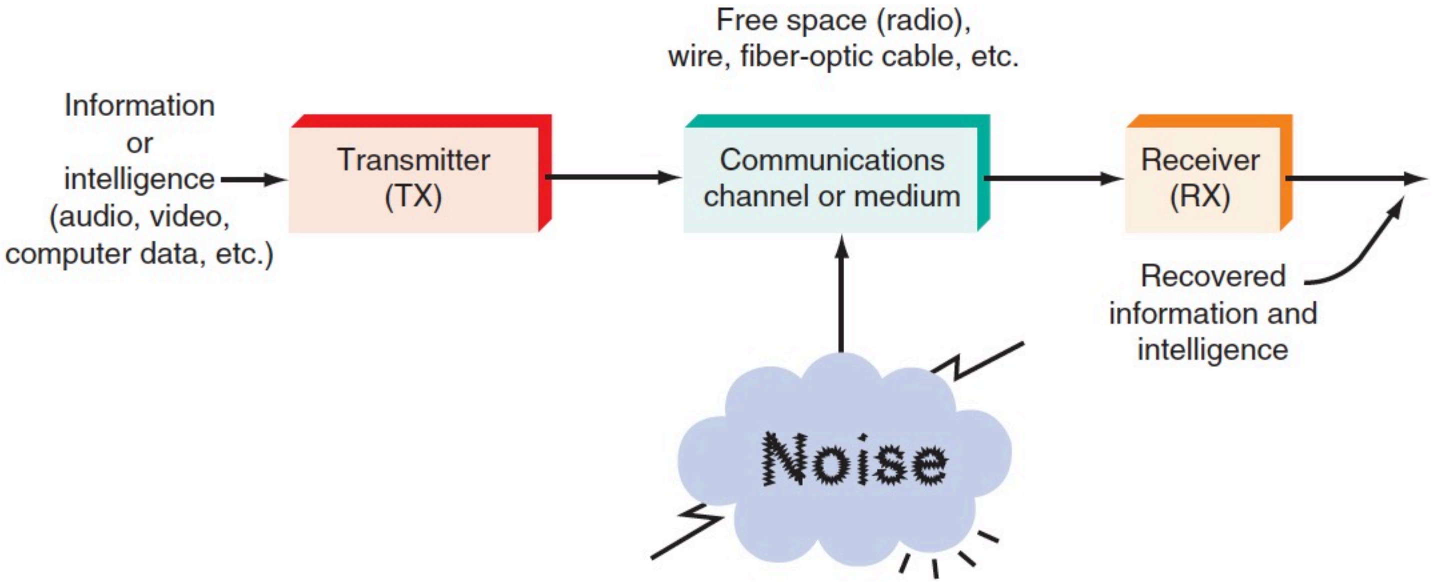
- Communication is the process of exchanging information.
- Two of the main barriers to human communication are language and distance.
- Long-distance communication was first accomplished by sending simple signals such as drumbeats, horn blasts, and smoke signals and later by waving signal flags (semaphores).
- Human communication took a dramatic leap forward in the late nineteenth century when electricity was discovered and its many applications were explored.
- The telegraph was invented in 1844 and the telephone in 1876. Radio was discovered in 1887 and demonstrated in 1895.

Significance of Communication (2)

- Well-known forms of electronic communication, such as the telephone, radio, TV, and the Internet, have increased our ability to share information.
- Our society is an information society, and a key part of it is communication.
- This course is about electronic communication, and how electrical and electronic principles, components, circuits, equipment, and systems facilitate and improve our ability to communicate.
- Rapid communication is critical in our very fast-paced world. It is also addictive. Once we adopt and get used to any form of electronic communication, we become hooked on its benefits. In fact, we cannot imagine conducting our lives or our businesses without it. Just imagine our world without the telephone, radio, e-mail, television, cell phones, tablets, or computer networking.

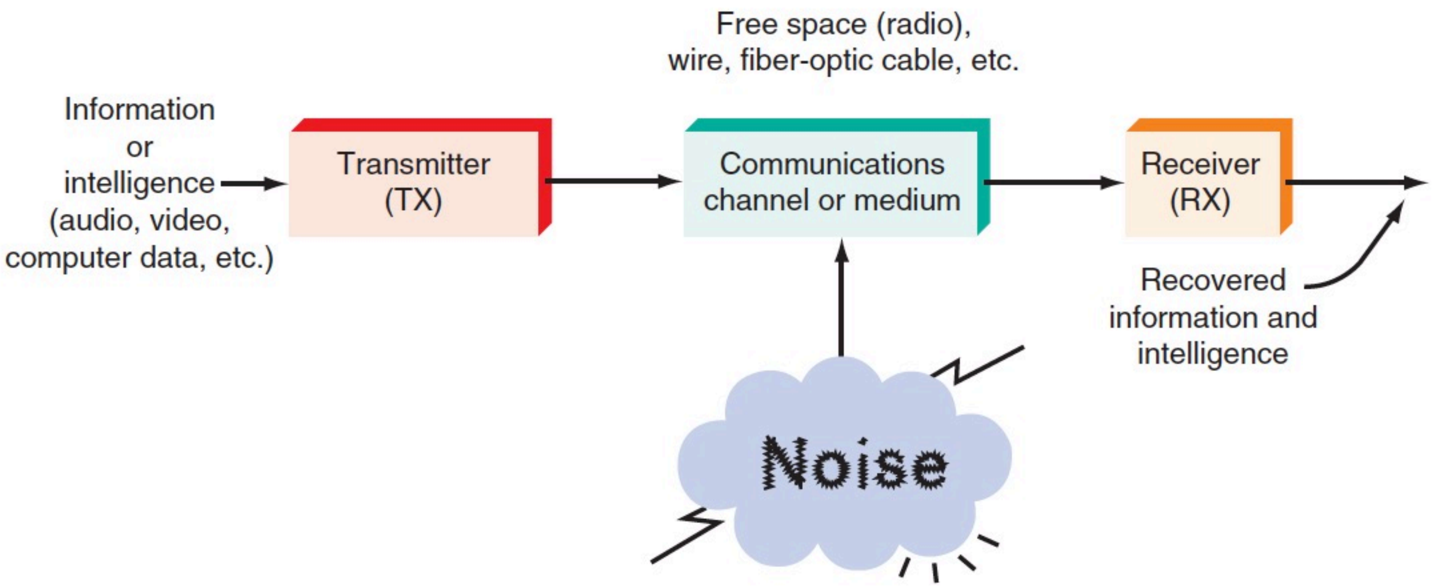
Communication Systems

- All electronic communication systems have a transmitter, a channel or medium, and a receiver.
- The process of communication begins when a human being generates some kind of message, data, or other intelligence that must be received by others.
- In electronic communication systems, the message is referred to as information, or an intelligence signal.

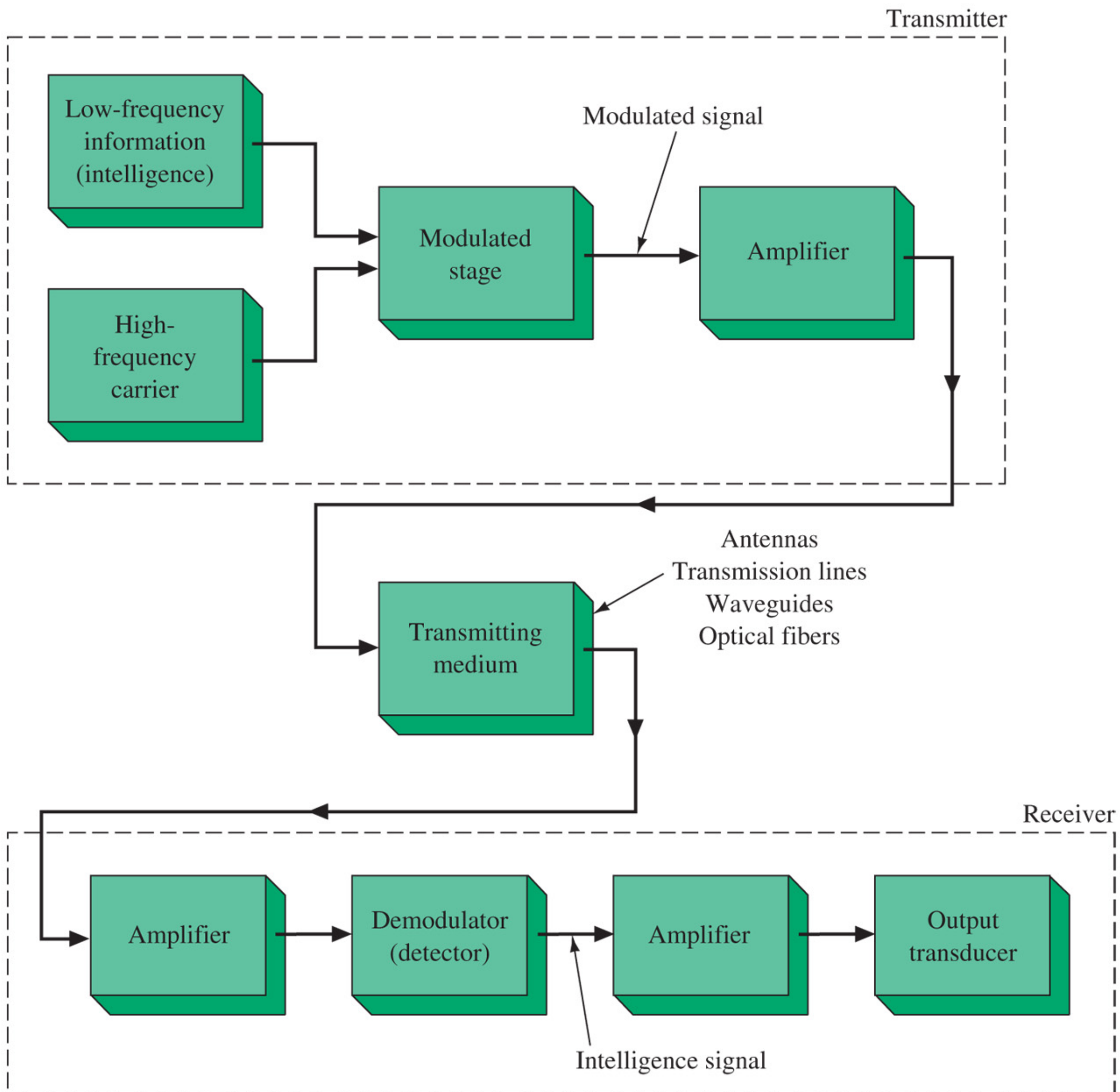


Communication Systems

- Message, in the form of an electronic signal, is fed to the transmitter, which then transmits the message over the communication channel, and picked up by the receiver.
- Along the way, noise is added in the communication channel and in the receiver.
- Noise is the general term applied to any phenomenon that degrades or interferes with the transmitted information.



Communication System



Transmitter

- The first step in sending a message is to convert it into electronic form suitable for transmission.
- Transducers convert physical characteristics (temperature, pressure, light intensity, and so on) into electrical signals.
- The transmitter itself is a collection of electronic components and circuits designed to convert the electrical signal to a signal suitable for transmission over a given communication medium.
- Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, frequency synthesizers, and other circuits.
- The original signal usually modulates a higher-frequency carrier sine wave generated by the transmitter, and the combination is raised in amplitude by power amplifiers, resulting in a signal that is compatible with the selected transmission medium.

Communication Channel (1)

- The communication channel is the medium by which the electronic signal is sent from one place to another.
- Many different types of media are used in communication systems, including wire conductors, fiber-optic cable, and free space.
- **Electrical Conductors:** In its simplest form, the medium may simply be a pair of wires that carry a voice signal from a microphone to a headset.
- **Optical Media:** The communication medium may also be a fiber-optic cable or “light pipe” that carries the message on a light wave. These are widely used today to carry long-distance calls and all Internet communications. The information is converted to digital form that can be used to turn a laser diode off and on at high speeds.

Communication Channel (2)

- **Free Space:** When free space is the medium, the resulting system is known as radio, also known as wireless.
- Radio is the broad general term applied to any form of wireless communication from one point to another.
- Radio makes use of the electromagnetic spectrum.
- Intelligence signals are converted to electric and magnetic fields that propagate nearly instantaneously through space over long distances.
- Communication by visible or infrared light also occurs in free space.

Communication Channel (3)

- In sonar, water is used as the medium.
- Active sonar uses an echo-reflecting technique similar to that used in radar for determining how far away objects under water are and in what direction they are moving.
- The earth itself can be used as a communication medium, because it conducts electricity and can also carry low-frequency sound waves.
- Alternating-current (ac) power lines, the electrical conductors that carry the power to operate virtually all our electrical and electronic devices, can also be used as communication channels.

Receivers

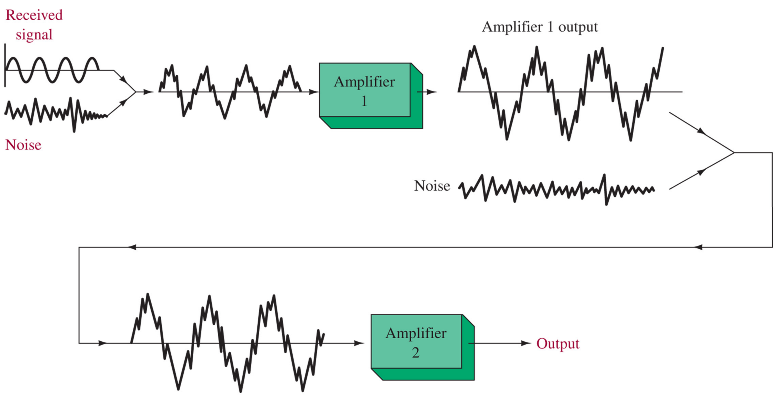
- A receiver is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back to a form understandable by humans.
- Receivers contain amplifiers, oscillators, mixers, tuned circuits and filters, and a demodulator or detector that recovers the original intelligence signal from the modulated carrier.
- The output is the original signal, which is then read out or displayed.
- It may be a voice signal sent to a speaker, a video signal that is fed to an LCD screen for display, or binary data that is received by a computer and then printed out or displayed on a video monitor.

Transceivers

- Most electronic communication is two-way, and so both parties must have both a transmitter and a receiver.
- As a result, most communication equipment incorporates circuits that both send and receive. These units are commonly referred to as transceivers.
- All the transmitter and receiver circuits are packaged within a single housing and usually share some common circuits such as the power supply.
- Telephones, handheld radios, cellular telephones, and computer modems are examples of transceivers.

Noise (1)

- Electrical noise may be defined as any undesirable voltage or current that ultimately end up appearing in the receiver output.
- To the listener this electrical noise often manifest itself as static.
- It may only be annoying, such as an occasional burst of static, or continuous and of such amplitude that the desired information is obliterated.
- Noise signal at their point of original are generally very small, for example, at the microvolt level, but it must be greatly amplified in the receiver before the final output.



Noise (2)

- Noise is the bane of all electronic communications.
- Its effect is experienced in the receiver part of any communications system.
- While some noise can be filtered out, the general way to minimize noise is to use components that contribute less noise and to lower their temperatures.
- The measure of noise is usually expressed in terms of the signal-to-noise (S/N) ratio (SNR), which is the signal power divided by the noise power and can be stated numerically or in terms of decibels (dB).
- Obviously, a very high SNR is preferred for best performance.

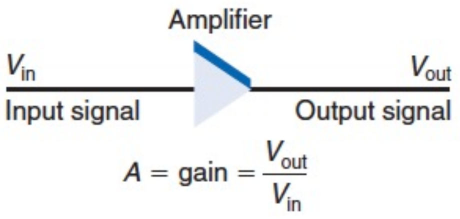
External and Internal Noise

- External noise: The noise present in a received radio signal that has been introduced in the transmitting medium.
  - Human-made noise
  - Atmospheric noise
  - Space noise

- Internal noise: The noise introduced by the receiver.
  - Receiver antenna
  - Thermal noise
  - Transistor noise
  - Frequency noise effects

Gain

- Gain means amplification.
- If a signal is applied to a circuit such as the amplifier shown in Figure and the output of the circuit has a greater amplitude than the input signal, the circuit has gain.



- Gain is simply the ratio of the output to the input.
- For input (V_{in}) and output (V_{out}) voltages, voltage gain A_V is expressed as follows:

$$A_V = \frac{\text{output}}{\text{input}} = \frac{V_{\text{out}}}{V_{\text{in}}}$$

- Since most amplifiers are also power amplifiers, the same procedure can be used to calculate power gain A_P:

$$A_P = \frac{P_{\text{out}}}{P_{\text{in}}}$$

Attenuation (1)

- Signal attenuation, or degradation, is inevitable no matter what the medium of transmission.
- Attenuation is proportional to the square of the distance between the transmitter and receiver.
- Media are also frequency-selective, in that a given medium will act as a low-pass filter to a transmitted signal, distorting digital pulses in addition to greatly reducing signal amplitude over long distances.
- Thus considerable signal amplification, in both the transmitter and the receiver, is required for successful transmission.
- Any medium also slows signal propagation to a speed slower than the speed of light.

Attenuation (2)

- Attenuation refers to a loss introduced by a circuit or component. Many electronic circuits reduce the amplitude of a signal rather than increase it.
- If the output signal is lower in amplitude than the input, the circuit has loss, or attenuation.
- Like gain, attenuation is simply the ratio of the output to the input. The letter *A* is used to represent attenuation as well as gain:

$$\text{Attenuation } A = \frac{\text{output}}{\text{input}} = \frac{V_{\text{out}}}{V_{\text{in}}}$$

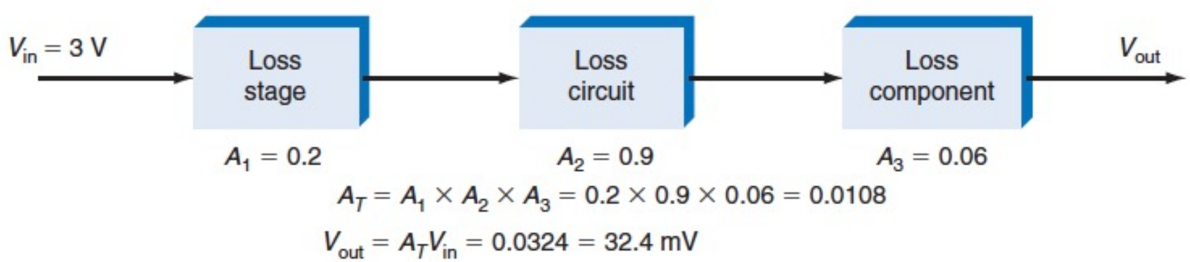
- Circuits that introduce attenuation have a gain that is less than 1. In other words, the output is some fraction of the input.

Attenuation (3)

- When several circuits with attenuation are cascaded, the total attenuation is, again, the product of the individual attenuations.

$$A_T = A_1 \times A_2 \times A_3$$

- The circuit in Figure below is an example. The attenuation factors for each circuit are shown. The overall attenuation is 32.4 mV.



Decibel

- The gain or loss of a circuit is usually expressed in decibels (dB), a unit of measurement that was originally created as a way of expressing the hearing response of the human ear to various sound levels.
- A decibel is one-tenth of a bel.
- When gain and attenuation are both converted to decibels, the overall gain or attenuation of an electronic circuit can be computed by simply adding the individual gains or attenuations, expressed in decibels.
- It is common for electronic circuits and systems to have extremely high gains or attenuations, often in excess of 1 million.
- Converting these factors to decibels and using logarithms result in smaller gain and attenuation figures, which are easier to use.

Decibel Calculation (1)

- The formulas for computing the decibel gain or loss of a circuit are

$$\text{dB} = 20 \log \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\text{dB} = 20 \log \frac{I_{\text{out}}}{I_{\text{in}}}$$

- Formula (1) is used for expressing the voltage gain or attenuation of a circuit;
- formula (2), for current gain or attenuation.
- The ratio of the output voltage or current to the input voltage or current is determined as usual.
- The base-10 or common log of the input/output ratio is then obtained and multiplied by 20.
- The resulting number is the gain or attenuation in decibels.

Decibel Calculation (2)

- The formulas is used to compute power gain or attenuation

$$\text{dB} = 10 \log \frac{P_{\text{out}}}{P_{\text{in}}}$$

- The ratio of the power output to the power input is computed, and then its logarithm is multiplied by 10.

Signal-to-Noise Ratio (SNR)

- Signal-to-Noise Ratio is a relative value measure of the desired signal power to the noise power. The SNR can be expressed mathematically as:

$$\frac{S}{N} = \frac{\text{signal power}}{\text{noise power}} = \frac{P_S}{P_N}$$

- At any particular point in an amplifier. It is often expressed in decibel form as:

$$\frac{S}{N} = 10 \log_{10} \frac{P_S}{P_N}$$

References

- *J. Beasley, G. Miller, "Modern Electronic Communication", Pearson, 9th ed. – Pages 1-17*
- Louis E. Frenzel, "Principles of Electronic Communication Systems", McGraw-Hill Education, *4th ed. – Chapter 1*