Introduction to Telecommunications Technology

Lesson 1

The first lesson in your study of telecommunications technology will introduce you to the basic aspects of electronic component noise and natural-source-based noise, bandwidth, filter, and oscillator circuits. These components and circuits make up the building blocks of all communication circuits—from the output stages of a transmitter to the input stages of a receiver. Both terrestrial and microwave satellite communications examples will be presented.

When you complete this lesson, you'll be able to

- Describe a basic communication system and explain the concept of modulation
- Understand the use of decibel (dB) in communications systems
- Define *electrical noise* and explain its effect at the first stage of a receiver
- Calculate the thermal noise generated by a resistor
- Calculate signal-to-noise ratio and noise figure for an amplifier
- Describe several techniques to make noise measurements
- Explain the relationship between information, bandwidth, and time of transmission
- Analyze nonsinusoidal repetitive waveforms via Fourier analysis
- Analyze the operation of various RLC circuits
- Describe the operation of common LC and crystal oscillators

ASSIGNMENT 1

Read this introduction to Assignment 1. Then study pages 1–17 in your textbook, *Modern Electronic Communication.* Complete "Questions and Problems" 2, 4, 18, and 19 on pages 61–62 in your textbook.

Designed to introduce you to the field of electronic communications, this assignment will present the concepts of modulation, frequency ranges, and electrical/electronic noise. A simple communication system, depicted in Figure 1-1 in your textbook, will prove helpful as you learn the necessary terms, components, and limitations.

Communication systems have come a long way from the early AM band radios that were present in many homes. These radios used batteries for power and vacuum tubes for amplifiers and detectors. The battery power was fed to a vibrating relay that turned direct current (DC) into alternating current (AC) to power the radio. Drawbacks of AM radio included significant static and hum, noisy, vibrating relay, and batteries that required frequent charging.

In the late 1950s, the AM radio gradually gave way to FM radio. Although these radios still used vacuum tubes, the power supply came directly from the home's 120 VAC electric system and was transformed to various voltages and rectified to power the radio. FM radio allowed for greater bandwidth, better filtering, and demodulation, resulting in less static and noise. At the same time, television was also becoming quite popular, with its VHF channels 2–13 and UHF channels 14–83.

Radio, television, and other forms of communication took another leap forward when the transistor was invented and developed, initially for the consumer market. Electronic circuits could then become more complex and miniaturized to provide smaller, more energy-efficient devices and portable battery-powered products.

Through further miniaturization, from the integrated circuit to the surface-mounted device level, high-performance analog, digital, and microwave devices have been created. These new devices offer clear, error-free communications over a wireless link to most parts of the world. This link can be from a transmission tower, satellite, cellular phone, or computer modem.

What do all of these communication devices have in common? Since the earliest days of communication, the system designer has looked for ways to eliminate noise from transmitted and received material or information. Early vacuum tube radios and TVs had radio frequency tuning and amplification stages built within vented metal boxes, and the tubes were covered with metal shields to reduce interference and noise. Many transistor-based circuits also used metal shielding in their front ends. Today's communication products require especially high-gain amplifiers, since the received signal is at a very small voltage level. Microwave receivers, such as those used in satellite TV, use special front-end stages called *low-noise amplifiers* (LNA or LNB). Special filters along with special low-noise components are often used in today's products.

After you've carefully read pages 1–17 in your textbook, *Modern Electronic Communication,* and answered all the assigned "Questions and Problems," check your answers against those provided in the Appendix of this study guide. When you're sure that you completely understand the material from Assignment 1, move on to Assignment 2.

ASSIGNMENT 2

Read this introduction to Assignment 2. Then study pages 18–27 in your textbook, *Modern Electronic Communication.* Complete "Questions and Problems" 23, 28, 31, 32, and 33 on pages 62–63 in your textbook.

The focus of this assignment is noise designation, calculation, and measurement. Two primary designations used for noise are *signal-to-noise (SN)* and *noise figure (NF)*. SN is normally used to designate how much noise is being produced by a receiver, amplifier, or other electronic circuit. NF is more useful when you're looking at particular electronic components (resistors, capacitors, diodes, transistors, and inductors) within a circuit. You'll also learn to calculate the thermal noise power for resistor combinations, reactance noise effects, and noise effects of cascaded amplifier stages. This assignment will then continue with a discussion on equivalent noise temperature and equivalent noise resistance. To help you master these topics, your textbook provides worked-out examples.

Your assignment will conclude with a presentation on noise measurement. Although expensive noise measurement instruments are often used for this form of electronic measurement, these instruments may not be available to you when they're needed. Figure 1-8 in your textbook will show you how to make fairly accurate noise measurements with a dual-trace oscilloscope, termed the *tangential noise measurement technique.*

After you've carefully read pages 18–27 in your textbook, *Modern Electronic Communication,* and answered all the assigned "Questions and Problems," check your answers against those provided in the Appendix of this study guide. When you're sure that you completely understand the material from Assignment 2, move on to Assignment 3.

ASSIGNMENT 3

Read this introduction to Assignment 3. Then study pages 27–34 in your textbook, *Modern Electronic Communication.* Complete "Questions and Problems" 39, 40, 41, and 43 on page 63 in your textbook.

The fundamental focus of this reading assignment is to demonstrate how information can be distorted, even have its form altered, if the transmission system lacks sufficient bandwidth. To illustrate this point, Figures 1-9 and 1-10 in your textbook show the modeling of a square wave using signals of wider and wider bandwidth. First, in Figure 1-9(a), a fundamental-frequency sine wave (which amounts to a very narrow bandwidth) is obviously a poor representation of a square wave. In 1-9(c), the addition of just three additional harmonics (still not a very wide bandwidth) results in a signal that at least mimics the appearance of a square wave. The same fundamental wave shown in Figure 1-9(a) along with 51 of its harmonics (spanning a correspondingly broader frequency range) is a fairly close approximation of a square wave. To help you better understand the bandwidth occupied by various signals, you'll be introduced to Fourier analysis of waveforms. Through this mathematical system of analysis, you'll be able to better visualize the concept of sinusoidal components combining to form a complex signal.

After you've carefully read pages 27–34 in your textbook, *Modern Electronic Communication,* and answered all the assigned "Questions and Problems," check your answers against those provided in the Appendix of this study guide. When you're sure that you completely understand the material from Assignment 3, move on to Assignment 4.

ASSIGNMENT 4

Read this introduction to Assignment 4. Then study pages 35–60 in your textbook, *Modern Electronic Communication.* Complete "Questions and Problems" 50, 51, 52, 56, 57, 58, 59, 66, 68, 69, 70, and 71 on pages 63–66 in your textbook.

During the final assignment of this lesson, you'll learn about LC circuits and oscillators and their basic characteristics. LC circuits make up the tuned stages you can find in any analog communications receiver's RF stages and in the oscillator in a transmitter. Your study of LC circuits will begin with the quality rating *(Q)* and dissipation *(D)* of inductors and capacitors, plus an introduction to how LC components form a resonance at certain frequencies. Next, the connection of RLC components, as they pertain to filters, will be discussed. You'll have an opportunity to practice calculating bandwidth, *Q,* component values, and resonant frequencies.

Oscillators are key elements in communication systems. Your textbook will provide an analysis of Hartley, Colpitts, Clapp, and crystal oscillators.

General troubleshooting techniques are skills that will be required of you throughout your career. Your textbook will detail the four types of circuit failures plus the four basic troubleshooting techniques. These techniques utilize a commonsense methodical approach to fault isolation. You'll learn that troubleshooting entails using not only electronic test equipment but also all of your senses. You can see trouble in the event of a burnt component; you can smell the characteristic odors of overheated components; you can feel the hot spots and hear the sizzle of a component about to fail.

After you've carefully read pages 35–60 in your textbook, *Modern Electronic Communication,* and answered all the assigned "Questions and Problems," check your answers against those provided in the Appendix of this study guide. When you're sure that you completely understand the material from these four assignments, you can complete the examination for Lesson 1.