Technician Minicourse

PRETEST TRAINING

Student Materials

TECHNICAL READING FOR TELECOMMUNICATIONS TECHNOLOGY

PREPARATION MATERIALS FOR THE TECHNICIAN MINICOURSE

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December, 1999

Technician Minicourse Test Preparation Package

This package includes materials that are designed to help you to prepare for the technician Minicourse. The Technician Minicourse consists of two modules. Each module provides instructional material that is read by the candidate under timed conditions. After reading the instructional material the candidate is then given a timed, multiple-choice test covering the material in the module. The material in this Test Preparation Package is similar to the type of material that you will encounter on the actual Technician Minicourse. There are two modules, each consisting of reading material, followed by a multiple-choice practice test. After you take the practice tests you can review the answers and the explanations that accompanies them.

The Technical Reading Telecommunication Technology course that you have completed will provide useful information in preparing for the Technician Minicourse. In the introduction to each Practice Module the key sections of the Technical Reading Telecommunication Technology course are referenced so you can review the concepts that you have learned.

Technician Minicourse

PRETEST TRAINING

MODULE 1:

Transmission Technology

STUDY MATERIAL

Module 1. Transmission Technology

This is the first module in the two-part review for the Technician Minicourse. In the minicourse you will be provided with self-instructional material from which to study. Upon completion of the minicourse you will be given a knowledge test measuring how well you have learned the material. This review is designed to prepare you for taking the minicourse. This review covers the same type of material as the minicourse as well as provides as practice test.

This module provides an overview of transmission technology and covers the following topics:

- Transmission Principles
- Copper Media
- Fiber Optics
- Power

Learning Objectives

When you have completed this module you should be able to:

- Describe the principles applicable to the transmission line
- Describe the identifying characteristics of transmission media
- Describe electron theory

Practice Test

The practice test is provided to support your learning of this module and to provide practice in test taking. The timed test will contain **30 questions** and you should give yourself **15 minutes** to complete the test. These are similar to the conditions you will encounter when you take the required knowledge test after the minicourse.

Technical Reading Telecommunication Technology Course

We also refer you to the Technical Reading Telecommunications course offered by Bell Atlantic. This course is designed to help you improve your ability to read technical material. As you progress through the course, you will be introduced to reading skills which are tools to help you better understand the material you are reading. In addition, you will receive a lot of valuable practice in reading the technical material and responding to the questions in the self-tests at the end of each lesson.

The following Books and Lessons with the Technical Reading Telecommunication Technology course will be particularly helpful in providing basic guidelines for reading technical material and in providing additional opportunities to take practice tests.

BOOK	LESSON
Book 1: Fundamentals	Lesson 1: Electron Theory Lesson 2: DC Circuits Lesson 3: AC Circuits
Book 3: Transmission Principles and Media	Lesson 1: Transmission Principles Lesson 2: Copper Media Lesson 3: Introduction to Fiber Optics

1. POWER

In this section you will learn about power, AC and DC current, circuits and other elements of power that are related to telecommunications systems. A basic understanding of the different aspects of the power system will give you a better overall understanding of telecommunications technology.

Although the practical use of electricity has become common within the last hundred years, it has been known as a force for much longer. The Greeks discovered electricity about 2,500 years ago. They noticed that when amber was rubbed with other materials, it became charged with an unknown force. The force had the power to attract other objects, such as dried leaves, feathers, or other lightweight materials. The Greeks called amber *elektron.* The word electric was derived from this word because like amber, it had the ability to attract other objects. It was not until the early 1600's that William Gilbert discovered that materials other than amber could be charged to attract other materials. He called materials that could be charged *elektriks* and materials that could not be charged *nonelektriks*.

In 1733 a Frenchman named Charles DuFay found that a piece of charged glass would repel some charged objects and attract others. These men soon learned that the force of **repulsion** was just as important as the force of **attraction**. Benjamin Franklin later made lists of materials that attracted and repulsed other objects.

Positives	Negatives
Glass rubbed on silk	Hard rubber rubbed on wool
Glass rubbed on wool or cotton	Block of sulfur rubbed on fur
Mica rubbed on cloth	Mica rubbed on dry wool
Asbestos rubbed on paper	Sealing wax rubbed on silk
Sealing wax rubbed on wool	Amber rubbed on cloth

Franklin called objects that attracted **positives** and objects that repulsed **negatives**. Any object attracted by a piece of glass rubbed on silk had a positive charge. Any object repelled by hard rubber rubbed on wool had a negative charge.

Today we understand that electricity is the flow of electrons produced by knocking the electrons of an atom out of orbit by another electron.

There are two basic types of electric current:

- AC - Alternating Current
- DC - Direct Current

Alternating Current

In the very early days of electric power generation, Thomas Edison, proposed powering the country with low-voltage direct current. His reasons were that low voltage current was safer for people to use than higher voltage alternating current. Nikola Tesla, a physicist, argued that direct current was impractical to use for large scale operations. Tesla, with his friend George Westinghouse was able to prove that alternating current was both feasible and inexpensive by winning a competition with Edison to provide electricity for the 1904 World's Fair. Alternating current thus became the standard type of electricity generated and distributed by electric power companies. Alternating current differs from direct current in that AC current reverses its direction of flow at periodic intervals. In addition to being cheaper to produce, alternating current has another, major advantage over direct current. It is easier to transform alternating current in comparison to Direct Current. AC current can be stepped up or stepped down depending upon the need.

Alternating current (AC) is a current flow that increases in magnitude from zero to a maximum, decreases back to zero, increases to a maximum in the opposite direction, decreases to zero, and then repeats this process periodically. One significant advantage of AC power is that it is easier to distribute to the customer. Alternating currents flow because the source of potential reverses itself. The alternation occurs when the source decreases to zero either uniformly or abruptly, and then changes polarity so that the current flow changes direction. The period in which current flows first in one direction and then in the other is called a cycle. One cycle of AC is completed when the source voltage rises to a maximum in one direction and falls to zero, then reverses itself to rise and fall in the other direction.

Direct currents are used in telephone circuits. DC current is a power source for relays and circuit components.

AC Distribution System

This system serves a dual purpose:

- The first purpose is it distributes the incoming AC power to various loads in the building.
- The second purpose of AC distribution system is that it protects cables and conductors from overload.

This is possible because the system contains fuses and circuit breakers to protect from overload.

DC Power

Electric current has been described as a flow of free electrons in a conductor connected to a source of electrical potential. As long as that potential is applied with the same polarity, the electric current will flow in one direction. This type of current is direct current or DC.

DC Power sources are: generators, rectifiers, converters, and batteries. Conductors are usually copper, but can be aluminum or any precious metals.

A *DC circuit* is one in which the electric current flow is always in one direction, from the negative pole to the positive pole. All electric circuits consist of three basic parts: a power source, conductors, and a load device.

The basic operation of an electrical circuit is best illustrated by example. An ordinary flashlight is a good example of a simple electrical circuit. A flashlight is powered by direct current (DC). The term "direct current" is explained later in this unit. Figure 1 illustrates the main components of a flashlight.

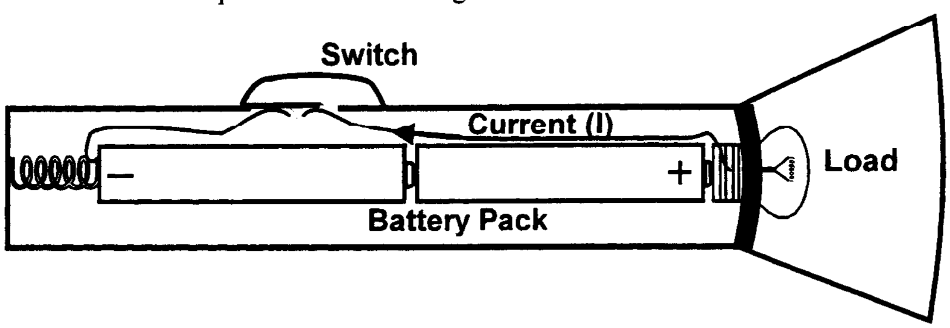

Figure 1

First , notice the wire (conducting material) connecting the battery pack to the bulb. The bulb is referred to as the load. A complete "go and return" path (also known as a "circuit") is required for electricity to flow between the battery pack (source) and the bulb (load). The switch is located in the circuit that connects the battery pack to the load. When the switch is open, the circuit from the battery to the load is broken, and electricity cannot flow. When the switch is closed, the circuit is no longer broken, which enables electricity to reach the load, illuminating the light bulb.

To simplify the discussion of the various parts of the flashlight circuit, it is helpful to work with a circuit diagram, rather than a sketch.

Figure 2 is a diagram of the flashlight circuit. —

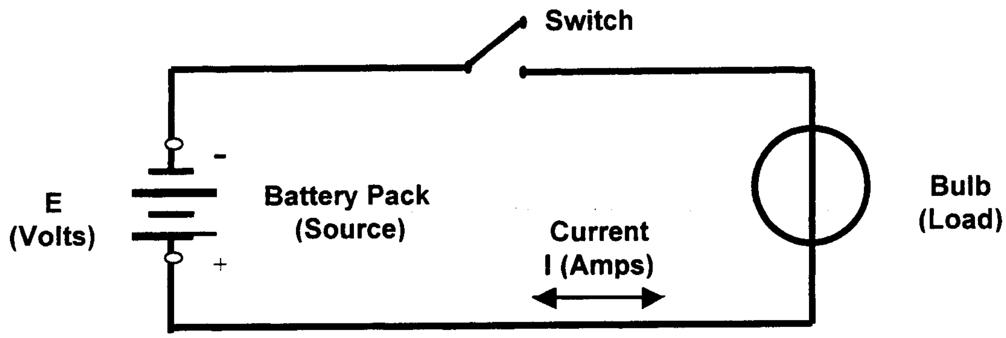

Figure 2

As you look at the circuit diagram, you can see that the circuit is composed of one wire that connects the positive (lower) terminal of the battery pack to the bulb. Another wire connects the opposite side of the bulb through the switch to the negative (upper) battery terminal. The wires are the conductors which conduct the electricity from the battery (source) to the light bulb (load). When the switch is open, the flow of electricity along the circuit path is interrupted, and the light bulb receives no electricity . But, when the switch is closed, a closed path (a circuit) is formed for electricity to flow from the battery through the wire to the light bulb and back to the battery. Now the bulb is illuminated.

The battery pack provides the electricity needed to activate the circuit. It is connected to the circuit at two different points called *terminals.* These are shown as hollow circles on the diagram. Chemical action within the battery pack creates a surplus of electrons at the negative terminal. Therefore, when a closed circuit is connected from the negative terminal to the positive terminal (by closing the switch, in this case), the *electrons flow from the negative terminal to the positive terminal through the circuit.* (By convention, the flow of current in a circuit is always shown in the direction from the positive terminal of the battery to the negative terminal, which is opposite to the flow of electrons.)
The wire, or filament, in the light bulb produces a high resistance, or opposition, to the flow of electrical current. This opposition allows the electrical energy of the battery pack to be converted into other forms of energy, such as heat and light.

An uninterrupted path is needed for electricity to flow in a circuit. A closed switch provides an uninterrupted path; an open switch interrupts the path. An electrical circuit with a single path for electron flow from source to load and back is called a ***series circuit.***

An electrical circuit that contains one or more points where the current divides and follows different paths is called a ***parallel circuit.*** In a DC (direct current) circuit, the current flows in only one direction. In an AC (alternating current) circuit, the flow alternates.

For current to flow in a circuit, there must be a complete path from the negative side of the power source, through the conductor and load, and back to the positive side of the source. If there is no complete path, current cannot flow and the circuit is said to be *open.*

DC Distribution System

The function of the DC Distribution system is to safely deliver adequate DC power from the rectifiers and batteries to the loads. This is the final link in the flow of power to the telephone equipment. The DC distribution includes three major components:

- Conductors — connect the power plant voltage to the load.
- Main Power Board — provides the protection, control functions and distributes DC power.
- Battery Distribution Fuse Board (BDFB) — are used when multiple loads are being served by one feeder circuit from the Main Power Board. This allows for fewer cable runs throughout the building, thus lowering operating expenses.

Summary

- There are two types of electric current: Alternating (AC) and Direct (DC)
- Alternating current reverses its direction of flow at periodic intervals
- Alternating current is cheaper to product and easier to transform up or down
- DC current occurs in circuits in which the electric current flow is always in one direction, from the negative pole to the positive pole.
- All electric circuits consist of three parts: a power source, conductors and a load device.
- The telephone transmitter is powered by a direct current source.
- An electrical circuit with a single path for electron flow from source to load and back is called a ***series circuit***.
- An electrical circuit that contains one or more points where the current divides and follows different paths is called a ***parallel circuit.***

2. SOUND

In this section you will learn:

- What sound waves are
- Types of sound waves
- How sound waves are measured
- An overview of telephone service

When a stone is dropped into a quiet pond, a set of waves spreads outward from the point of impact in ever-widening circles. The size of each circular ripple grows at a constant rate. A floating chip of wood does not move forward with the waves that strike it but merely bobs up and down, scarcely moving from its place.

Besides waves on water, there are other types: light, X-rays and radio are also forms of wave motion as are **sound waves**.

Sound Waves

Suppose that instead of tossing a stone into a pond we explode a firecracker outdoors. The sudden explosion compresses the air nearby. Air, being highly elastic, expands outward and in doing so, compresses the layer of air just beyond. The state of compression is handed on and spreads rapidly outward in much the same way as the ripples spread out over the surface of the pond. Here, however, we have a wave of compression, for that is exactly what a sound wave is. As it passes, the molecules of the air crowd together, then draw apart. The sensation of hearing results when such waves strike the ear.

Compression waves (sound waves) can travel through solids and liquids as well as through gases such as air, since all substances are elastic to some extent; but some material is always needed as a carrier. This is because sound is a mechanical process that actually moves molecules of whatever substance is carrying the sound. Experiments have shown that sound cannot not travel in a vacuum because there are no molecules to move.

Continuous Waves

The disturbance produced by dropping a stone into water consists of only a few crests and hollows. If continuous waves are to be formed, a steadily **oscillating** or vibrating body must be allowed to dip into the water. The exact same thing is true of sound waves. Sustained sound comes from sources such as vibrating bells, violin strings or drum heads.

Suppose a small rubber balloon is partly inflated and attached to a hand pump. If the handle is quickly pushed down a short distance, the balloon expands and the outside air in contact with it is suddenly compressed. This layer of air will, in turn, compress the layer beyond it, and so on. The compression that was started by the swelling of the balloon will thus travel away from the balloon in all directions. Similarly, if the handle is quickly pulled up a short distance the balloon contracts and the adjoining air suddenly expands.

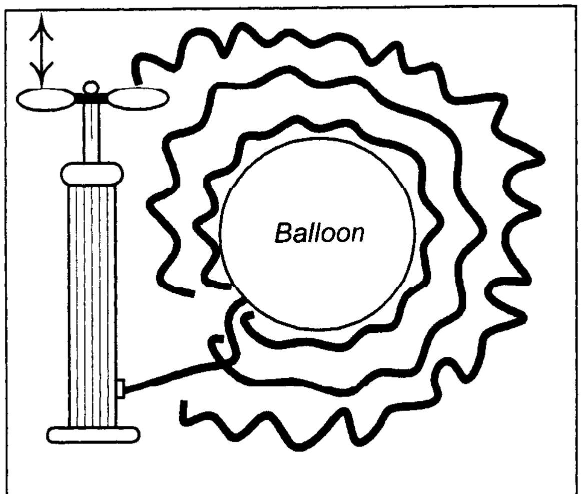

Figure 3

This time, a region of low pressure spreads outward in all directions. Moving the handle up and down in regular intervals makes a succession of compressions and expansions travel out from the source. Such a regular train of disturbances constitutes **continuous wave motion**. If the up-and-down motion of the handle could be made rapid enough a nearby observer would hear sound as these compression waves reach the ear. Similar effects are produced by vibrating violin strings, a guitar or the human voice.

In any wave motion, no particle of the material that is carrying the waves ever moves very far from its normal place, but is merely displaced a short distance, first one way and then the other. In sound waves, the particles oscillate along the line in which the waves are moving. When waves are sent out by a vibrating body, the number of waves produced in one second is the same as the number of vibrations per second, or **frequency** of vibration of the source. The **wavelength** is defined as the distance between two successive places in the wave train that are in the same state of compression. In Figure 4 the wavy line is a graph of the way the pressure in the wave changes.

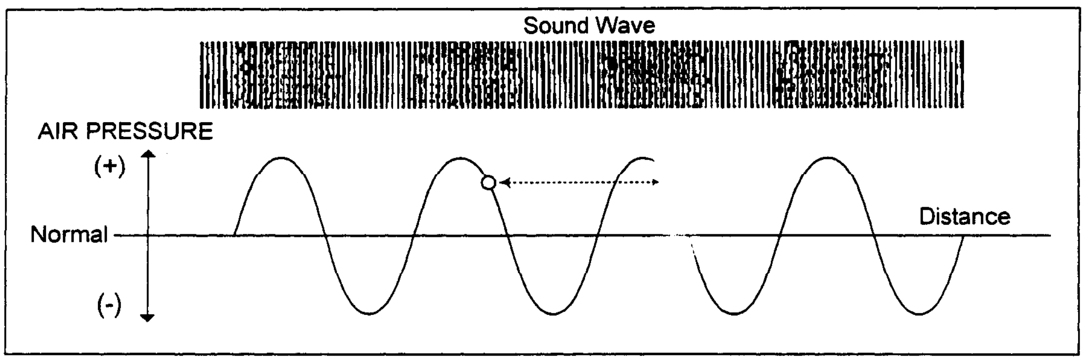

Figure 4

The height of the curve at any point gives the pressure, above or below, normal air pressure, at that place in the wave train. The distance between any two crests (or troughs) is one wavelength.

Telephone Service

Although much of this module will discuss transmission principles it is useful to begin with an overview of how telephone service actually works. Figure 5 shows the path that telephone service takes from the central office to the customer. Telephone service begins in the central office, where there is a power source and where all of the connections that allow telephone calls to be made are housed. Note that there are two "wires" that go from the central office to the customer premise. These two wires are called the *tip* (the send line) and the *ring* (the receive line). The wires are housed in cables that go from the central office to the customer premise. The cables may be *aerial* cables strung on poles, as shown in Figure 5, or they may be underground cables. From the cable, wires are connected to the telephone handset on the customer premises. This entire system is sometimes referred to as the *local loop*. The remainder of this module will discuss the principles by which voice and data are transmitted throughout the entire system.

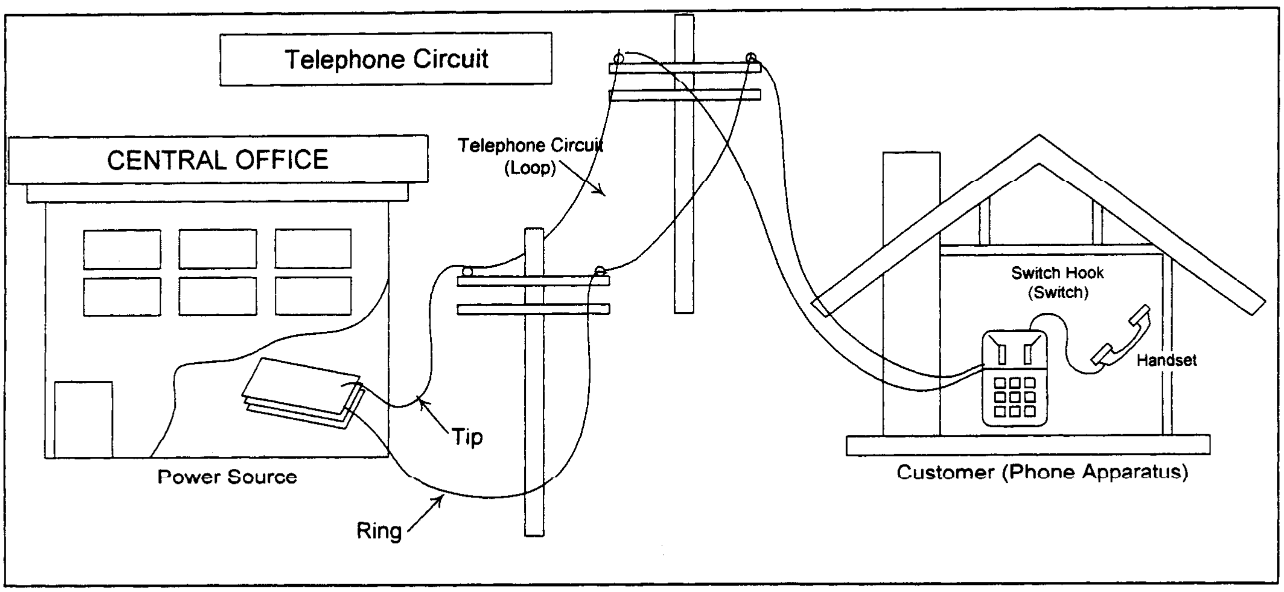

Figure 5

Summary

- Sound waves are continuous waves that can be measured with frequency and wavelength.
- Frequency is measured by the number of waves produced in one second.
- The wavelength is defined as the distance between two successive places in the wave train that are in the same state of compression.
- Telephone service begins in the central office where all telephone calls are connected.
- The tip and ring are two wires that go from the central office to the customer premise and are part of the system known as the local loop.

3. TRANSMISSION PRINCIPLES

In this section, you will learn some of the principles applicable to the transmission line.

A transmission system consists of three parts:
- source of energy
- line over which to send that energy
- receiving device

The transmission line or transmission medium is used to carry information in the form of voice, music, pictures, etc. from one location to another. The transmission line can be as short as a few feet or as long as several thousand miles, and can be made of paired cable, coaxial cable, microwave radio, or optical glass fiber.

This section describes some of the characteristics of signals and transmission lines. The purpose of any transmission line is to act as a conducting path for an electronic signal.

ANALOG TRANSMISSION
The purpose of the ideal transmission path is to deliver an accurate reproduction of the original signal to the receiving terminal. Electronic signals are generated in a variety of forms such as sine waves, voice waves, etc. These waveforms are called *analog* waveforms.

The analog waveform is an electrical signal that represents electrically some other form of change or movement. That change could be sound pressure, light intensity, heat change, pressure change, physical movement, etc.

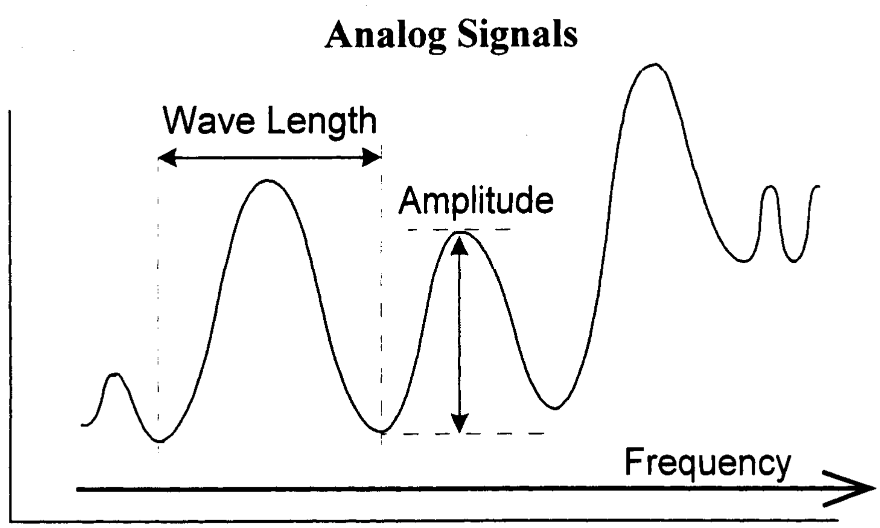

Figure 6

In telecommunications, the analog signal usually starts with the human voice spoken into a transmitter.

How does the transmitter actually change your voice into an analog signal? Speech, like any sound, is created by something vibrating. In the case of speech, your vocal cords push air molecules together as they move one way and increases the distance between these molecules as they move in the other. These compressed and expanded segments of air moving away from the vibrating object are called sound waves.

The sound waves strike a diaphragm in the mouthpiece of the telephone, making the diaphragm move in and out with the same frequency as the sound waves hitting it. Behind the diaphragm are tiny carbon granules which are alternately compressed and released. Since compressing carbon molecules decreases their resistance to electric current, the movement of the diaphragm is directly translated into alternately increased and decreased flow of electricity. In the receiver, this electricity is translated by an electromagnet back into sound waves.

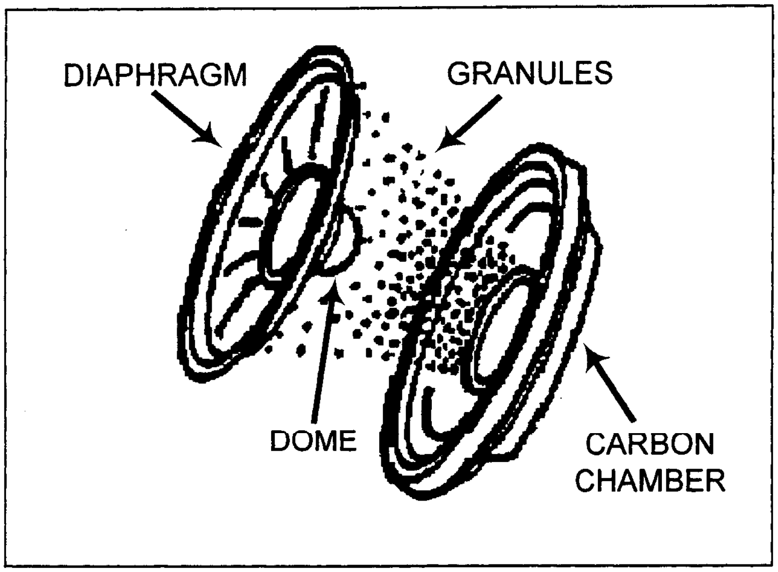

Figure 7

From the transmitter, this analog signal may go through many changes as it passes down the transmission line. These changes can be imposed by amplifiers, carrier systems, radio systems, etc., but in the end, under ideal conditions, an exact reproduction of the original signal enters the telephone receiver and converts to air pressure in the ear of the listener. Aside from loss (or attenuation), analog signals are impaired by noise and distortion. Amplifiers and other apparatus used for analog signals are complex because of the need to control noise and distortion.

Noise is a term for unwanted electrical signals that interfere with the information signal. In transmission lines, noise comes from electrical influences such as power lines, lightning, commercial radio transmitters, and crosstalk between lines.

Distortion is an unwanted change in the information signal waveform. Distortion of analog signals occurs because amplifiers and other apparatus, as well as the cable pair, do not reproduce all frequencies equally well, resulting in changes in the waveform.

Loss can be overcome by using an amplifier to restore the signal to its original amplitude. However, since the amplifier cannot differentiate between signal and noise, it amplifies the noise as well as any distortion in the signal. The amplified noise and distortion then become part of the input signal for the next section of the analog transmission line.

As we increase the length of the analog transmission line, we must use more amplifiers, and the effect of noise and distortion accumulates. The cumulative effect can be minimized by proper system design, but it cannot be eliminated. Noise and distortion generally limit the maximum length of an analog transmission system.

Analog signals can be mixed together using *frequency division multiplexing* (FDM), although this process is not often used any more as digital transmission becomes more common. In FDM, multiple voice channels are combined into a single signal which is carried over a link thus making the most efficient use of that link. Each low-speed voice channel is modulated on a separate frequency within the bandwidth of the line, thus keeping the channels apart and preventing crosstalk. At the remote end, the channels are *demultiplexed* or separated again.

The current coming into the receiver passes through the electromagnet which is positioned in the field of the permanent magnet. This causes variations in the magnetic field making the diaphragm vibrate and this generates sound waves like the ones that were transmitted by the person speaking. This produces speech at the receiving end.

DIGITAL TRANSMISSION

Digital transmission is a means to transmit analog signals (voice) by converting the signals into a series of electrical pulses. The pulses are transmitted to a distant point, which are then converted back to the original analog signal.

What is a digital signal? It is simply a series of square wave pulses sent at a very high speed down a transmission line. The pulses are identical in shape with alternate pulses reversed in direction. These pulses represent pieces of information called *bits*. This word comes from the letters of the two words binary digit. A pulse or no pulse condition is known as a bit. In digital signals, a one is normally a pulse and a zero means no pulse (in some applications, these are reversed).
Digital signals or pulses are subject to the same loss, noise, and distortion problems as analog signals. Attenuation losses, however, are corrected by the use of regenerative

repeaters instead of amplifiers. Noise and distortion are not a problem because when each distorted pulse arrives at the regenerator, it is reconstructed into a distinct pulse and sent on its way to the next regenerator or to the termination point, as shown in Figure 8.

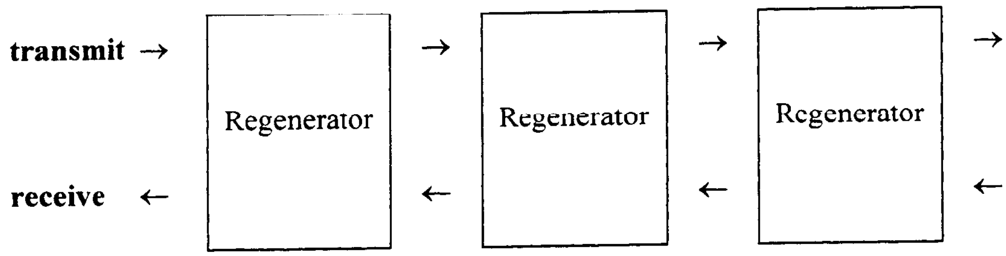

Figure 8

The pulse is therefore regenerated (rather than amplified) at the repeater, and the effects of transmission impairments (noise and distortion) are eliminated.

There are several very important reasons for using digital transmission. They are:
- lower cost than analog
- free from distortion and noise
- easier to multiplex (mix) with other signals

Analog transmission has existed since the invention of the telephone and will continue for some time in the future, but digital will eventually replace all analog systems. Digital signals are used in T-Carrier, Subscriber Loop Carrier (SLC) systems and fiber optic systems. In the T-Carrier system with 24 channels, 1,544,000 bits per second are sent over the line. This is a 1.544 megabit rate.

Summary
- A transmission line is a conducting path for electronic signals.
- Transmission lines are made of paired cable, coaxial cable, microwave radio, and fiber optical glass.
- Analog signals are electric signals that closely reproduce changes in sound pressure on telephone transmitters and other mechanical movement.
- Analog signals are subject to noise and distortion.
- Digital signals are high speed square wave pulses that can be derived from sampling analog signals.
- Digital pulses are regenerated rather than amplified.

4. COPPER MEDIA

INTRODUCTION

In this section, you will learn about copper wire — once the only transmission medium — and the effect of the line on the quality of the transmitted signal.

What do we mean when we talk about *media*? Media is a generic word meaning paths or ways to get from here to there. "Media" is actually plural; the singular form is "medium." When we talk about transmitting signals, the media are the physical paths that the signals follow between transmitter and receiver.

The media that have commonly been used for voice and data networks are twisted pair, coaxial cable, and optical fiber. Each type serves some applications better than the others. Twisted pair and coaxial cable are based on copper wire and are the media we are most familiar with. Optical fiber (also known *fiber-optic cable* or just *fiber)* will be covered in a later section.

TWISTED PAIR WIRE

Twisted pair wire consists of two insulated copper wires arranged in a regular spiral pattern. Most telephone equipment requires two wires for operation. The two wires are twisted together to reduce capacitance that can build up between the wires and weaken the signal. Capacitance is an object's ability store electrical charge. The signal in twisted pair wire can also be weakened by electrical interference (noise) from outside sources. Noise can be prevented by putting a shield around the twisted pair, but shielding increases the cost of the wire. Therefore, *unshielded twisted pair (UTP)* is commonly used for telephone sets.

Typically, a number of wire pairs are bundled together into a *cable*. A cable is a group of insulated wires formed into a compact core and covered with a flexible, protective, waterproof sheath or covering. The number of wires in a cable can vary from 25 to over 2000. Cables are described by pairs rather than individual wires, so a cable with 50 wires would be called a 25-pair cable. The number of pairs is important because most telephone equipment requires at least two wires for operation.

The two wires are the tip and ring. The tip and ring are the transmit and receive lines for the signal. Together with the Central Office (CO) and the customer premises, they make up the local loop.

Twisted pair wire can also be used for Local Area Networks (LANs). It is the least expensive medium for LAN installations and also the most available. Twisted pair wire is best for low-cost, short-distance LANs, especially for small networks linking personal computers. It can effectively carry data at rates up to 16 Megabits per second (Mbps) over distances up to several hundred feet without repeaters.

Standard twisted wire has, however, several significant disadvantages for data transmission. First, it is extremely susceptible to electrical interference (noise) from outside sources. Second, it limits the distance that a signal can travel. A signal will grow weaker, or attenuate, as it travels further from its source. Signals attenuate on all media, but twisted pair wire acts as an antenna: the longer it gets, the more noise it gathers. After a finite distance, the increased noise obliterates the attenuated signal.

Two techniques can reduce the vulnerability of twisted pair to noise: shielding and repeating. Shielding makes the medium less vulnerable to electrical noise, but adds to the cost of the wire. Active repeaters, devices that receive a signal and retransmit it to another length of wire or cable, increase the distance a signal can travel. Repeaters are expensive and add to the cost of running twisted pair wire.

COAXIAL CABLE

Generally used in voice networks for inter-office trunks, *coaxial* cable (also called *coax*) comes in many forms and each is suited to a different kind of application. All forms of coaxial cable are comprised of a center conductor made of copper that carries the signal, the surrounding dielectric (a non-conducting insulator), a solid woven metal shielding layer, and a protective plastic outer coating. All these layers are concentric around a common axis, thus the term "coaxial". Coaxial cable is immune to electrical noise and can carry data at higher rates over longer distances than twisted pair wire, but is more expensive.

Coaxial cable is the most versatile transmission medium. There are two types of coaxial cable currently in use for LAN (Local Area Network) applications: 75-ohm cable, which is the standard used in community antenna television (CATV) systems, and 50-ohm cable. Typically, 50-ohm cable is used for digital signaling, called baseband; 75-ohm cable is used for analog signaling, called broadband. The term “Ohm” refers to a standard unit of measurement of an object’s resistance to the flow of a steady electric current.

TRANSMISSION LOSS

A transmission line is like an obstacle course in that it hinders the flow of electronic signals. The greatest effect on the signal is the loss of intensity as it travels down the line.

This loss of intensity is the result of several factors:

- resistance
- capacitance
- inductance

Cable pair transmission lines come in a variety of forms depending on the size of the conductors and the internal structure of the cable.

All transmission lines have a measurable impedance called *characteristic impedance.* In telecommunications, several characteristic impedances are used depending on the type of line. For example:

600 ohms	interoffice trunk
900 ohms	subscriber cable
1200 ohms	carrier systems

In a 600 ohm transmission line, the measurement is the same in either direction in order to obtain the most efficient transfer of power (least resistance) down the line. The input and output devices must also be 600 ohms.

This is called *impedance matching* and is very important when a transmission system is installed or when a transmission measurement is to be made. If mismatched components are connected together, a reflection or echo will occur, and customers will sound as if they were speaking into a barrel. Therefore, impedances must be matched to assure quality of transmission.

Transmission line losses and gains are not measured in volts but are measured in units of power. Power is the product of current and voltage and the unit used is the watt or, more appropriately for telecommunications, the *milliwatt* which equals one-thousandth of a watt.

Decibel (dB) is the name used to define the amount of power in transmission Lines. The decibel, in relationship to transmission lines, refers to the amount of loss or gain in the line from the input end to the output end.

In normal practice, gains are shown as +dB, but losses do not use the negative sign (-).

SUMMARY

- A transmission line is a conducting path for electronic signals.
- Transmission lines are made of paired cable, coaxial cable, microwave radio, and optical glass fiber.
- Twisted pair wire consists of two insulated copper wires arranged in a regular spiral pattern.
- The cable pair (tip and ring), the Central Office (CO), and the customer premises make up the local telephone loop.
- The disadvantages of twisted pair are susceptibility to noise and limited distance. Shielding and the use of repeaters compensate for these disadvantages.
- Coaxial cable is made up of a central copper conductor that carries the signal, the surrounding dielectric (a nonconducting insulator), a solid woven metal shielding layer, and a protective plastic outer coating.
- Coaxial cable is immune to electrical noise and can carry data at higher rates over longer distances than twisted pair wire, but is more expensive.
- Transmission line loss is caused by resistance, capacitance, and inductance.
- Transmission lines have a fixed impedance depending on their usage.
- Failure to match impedances in transmission lines will result in echo and distortion.

5. FIBER OPTICS

In this section you will learn about optical fiber, the various types of fiber and how transmission though fiber optic cable works.

Optical fiber is the newest and most expensive transmission medium, but it has the greatest potential. As the cost comes down, fiber will become the primary medium for telephone systems. Its greatest advantage is that fiber is immune to both physical and electrical interference. Fiber is more fragile than copper wire, but recent advances in technology have made optical fiber sturdier than it used to be. You can actually tie it in a knot without damaging it.

Optical fiber transmits a signal-encoded beam of light by means of total internal reflection. If you shine a flashlight in one end of a piece of optical fiber, you can see the light come out at the other end. To send information over fiber, we convert the pulses of electricity to pulses of light, using the same on/off pattern we used for digital data. The optical fiber acts as a wave guide for frequencies in the visible spectrum and part of the infrared spectrum. The advantages of optical fiber are greater bandwidth, smaller size, lighter weight, lower attenuation, electromagnetic isolation, and greater repeater spacing.

HISTORY OF OPTICAL COMMUNICATIONS

The concept of using light for communications is not new. In 1880, Alexander Graham Bell demonstrated a system he called a "photophone." It focused sunlight as a source and sent a beam of light through the air to a detector. Bell's invention was not practical because the source and medium were not reliable on foggy or rainy days or (of course) at night. It wasn't until the 1950's and 60's that the concept of practical optical communications became feasible. The laser was invented by Bell Laboratories in 1958. Corning Glass Company produced the first practical low-loss fiber in 1970. The first continuously operating semiconductor laser operating at room temperature was also demonstrated at Bell Laboratories in 1970.

Through the early seventies, more strides were made and more processes developed for the making of practical, low-loss fibers. In 1976, an experimental fiber optic communication system was developed in Atlanta. A trial system was deployed in Chicago in 1977. The first Bell System standard 45 Mbps (million bits per second) system was put into service in Atlanta in 1980. As you can see, significant strides in several areas have been taken to produce practical fiber optic communications systems over the past 20 years. Advances in technology are being made every day and will affect this mode of communication for many years to come.

FIBER CONSTRUCTION

An optical fiber is a thin, flexible medium capable of conducting an optical ray. Various glasses and plastics can be used to make optical fibers. An optical fiber cable has a

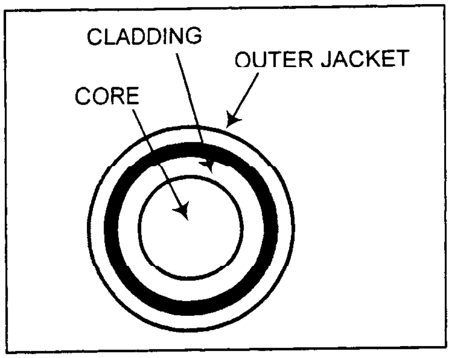

Figure 9

cylindrical shape and consists of three concentric sections: the core, the cladding, and the jacket.

- The *core* is the innermost section and consists of a very thin glass or plastic strand (or fiber). The core is typically from about 8 to 62.5 µm (micrometer) in diameter.

- The core is surrounded by the *cladding,* a glass or plastic coating with a typical outside diameter of 125 µm.

- The outermost layer, surrounding one or a bundle of cladded fibers, is the *jacket* giving a total fiber diameter of 229 µm or more (almost one hundredth of an inch). The jacket is composed of plastic and other materials layered to protect against moisture, abrasion, crushing, and other environmental dangers.

Sometimes a layer of *kevlar* fibers is included between the cladding and the jacket for additional protection. Kevlar is the material used to make bullet-proof vests.

Light propagates (travels) along an optical fiber in the form of light rays. Each light ray (***mode***) that enters the core of an optical fiber will propagate along a path determined by the angle at which it enters the fiber and the characteristics of the fiber itself. Each mode carries an individual (but not equal) portion of the total light energy, and each mode follows an individual path. The light rays or modes stay within the core because the core is very transparent while the cladding is reflective. The cladding acts like a mirror around the core, creating a channel that keeps the light energy concentrated in the core.

There are two basic types of optical fibers used in the telephone business today: multimode fibers (including enhanced multimode fibers) and singlemode fibers.

Multimode Optical Fiber

Multimode fibers can accommodate transmission at 825, 875, and 1300 nanometer (one billionth of a meter) wavelengths. The common bit-rate for a multimode fiber is usually either 45 Mbps or 90 Mbps. The larger core (62.5 µm) is used in *enhanced multimode fiber* (also known as "fat fiber"), which was developed for use in the loop plant, specifically for pair gain fiber optic systems. The larger diameter core permits more light to be coupled into the fiber, thus reducing the need for regenerator stations in the loop plant.

When these fibers were originally manufactured, a *step-index* process was used in which all of the layers of the core refracted light the same way. Each mode followed a separate propagation path and some had further to go than others, so all of the modes did not arrive at the receiving end at the same time. The longer the fiber, the longer it took these modes to reach the receiving end, causing the output pulse to widen as multiple pulses overlapped. This condition, called *modal dispersion,* shortens the required distance between regeneration points and limits the bandwidth potential. For this reason, step-index fiber is not suitable for use in multimode communications circuits.

Multimode fibers are now manufactured as *graded-index fibers,* which improves the poor transmission characteristics of step index fibers. The index of refraction is lower in the outer rings and becomes progressively higher toward the center. The center of the core will possess the highest refractive index. This will cause those modes that propagate down the center (shorter path) of the fiber core to travel at slightly lower speeds than those that take the longer paths. This controls the propagation velocity so that all modes arrive at the receive end of the fiber at virtually the same time, thus allowing regenerators to be spaced further apart.

TYPICAL FIBER OPTIC SYSTEM

A basic communications systems consists of:

- an electrical ***input*** signal which contains the information that is to be transmitted over the system.
- *a transmitter* that converts the signal into a suitable format for transfer. In a fiber optic system, the transmitter is an electrical-to-optical transducer or *light source* which converts electrical energy to optical energy. A ***transmitter*** is a component that converts one form of input energy into another form of output energy.
- *a transmission medium.* In a fiber optic system, this medium must be suitable for the transmission of optical energy (such as a glass fiber).
- *a receiver* that extracts the message from the medium and formats it. In a fiber optic system, the receiver is an optical-to-electrical transducer or *photodetector* which converts the light energy back to electrical energy.
- an electrical *output* signal which is ideally a replica of the original input signal.

A typical lightwave system includes:

- an electrical input signal that contains the information being transmitted.
- an electrical-to-optical transducer that converts the digital electrical signal to optical energy.
- a medium suitable for transmission of optical energy (fiber optic cable).

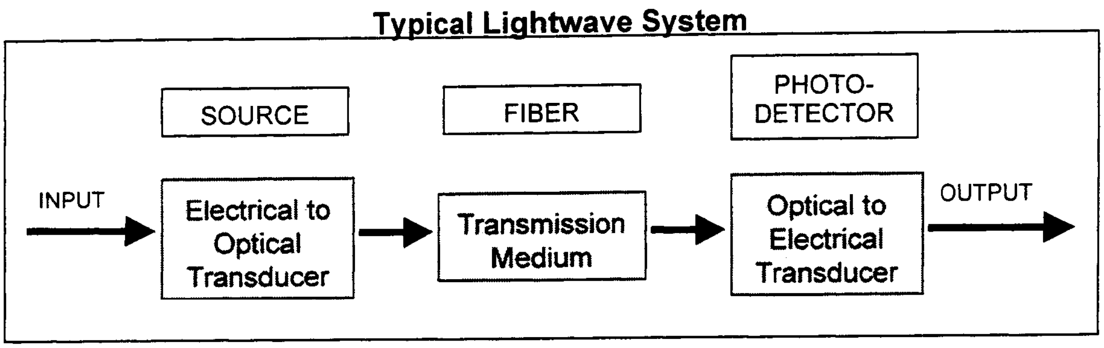

Figure 10

The input signal (electrical energy) is changed to optical energy by the electrical-to-optical transducer, referred to as the optical source. The most common optical sources used in telecommunications systems are semiconductor lasers and light emitting diodes (LEDs).

Any medium that transmits light signals could be used. One such medium is air. Air is suitable for applications such as ship to ship blinker communication. However, digital transmission of voice and data require a more dependable, high capacity transmission medium. Low loss optical fiber has been developed for this purpose.

The average amount of information sent by a ship's blinker light is about 12 words per minute, or one character per second. In digital technology we refer to the speed of transmission in terms of bits per second. Thus, a ship's blinker would transmit at about 1 bit per second. In contrast, optical fiber systems can transmit information at the rate of millions of bits per second. This is abbreviated as Mb/s. For example, 500 million bits per second would be transmitted as 500 Mb/s. We also use the term megabit to refer to the speed of transmission. Thus, 500 million bits per second could also be referred to as a rate of 500 megabits.

All of the major elements in any fiber optic system are identified above. A fiber optic communication system is designed so that its source, fiber, and photodetector are compatible. The source and photodetector must emit and collect light at the wavelengths that are most suitable for optical transmission. The input signal can be either analog or digital. Most fiber optic systems, however, are designed to transmit digital signals.

ADVANTAGES OF FIBER OPTIC SYSTEMS

Fiber optic transmission systems are superior to copper systems in many ways, such as:

- They can carry large amounts of data, so they can support high capacity systems. Copper cable has a very limited capacity compared to fiber.

- Cables are of a small size and lightweight. Fiber optic cables are about one-half inch in diameter (regardless of the number of fibers) and weigh about 82 lbs. per 1000 feet. This factor in itself lowers transportation and handling costs.

- They provide service at a low cost per channel. Long-term cost benefits associated with fiber optic systems include:
  - Lower construction costs due to tremendous savings in duct space. Three fiber optic cables can be placed in a four-inch duct that formerly could support only one copper cable.
  - The high bandwidth capacity of fiber optic cable reduces the need for placing additional cables in the future.
  - Fewer repeater sites are required. A typical fiber optic system requires one repeater every twenty-five miles while <u>twenty-two</u> repeaters are required for copper systems over the same distance.

Fiber optic systems are immune to the following electrical problems:

- radio frequency interference (RFI) and electromagnetic interference (EMI). RFI are emissions from electronic equipment, while EMI are emissions from natural phenomena like thunderstorms or caused unintentionally like static.

- crosstalk

- safety problems like electrical sparking or shock.

- Fiber optic systems are reliable. They can tolerate higher temperatures than copper and do not rust. The jacket prevents water from contacting the core and interfering with the signal.

- They are more secure than copper systems. Copper systems allow signal emissions which can be picked up by "bugs," but very little light energy radiates out of the fiber core, making interception of the signal virtually impossible.

There are a few disadvantages of fiber. It is still somewhat more expensive than cable, though prices are changing. The optical connector is expensive and is the main cause of signal loss. Also, it is more difficult to tap into a fiber than a copper cable.

Optical transmission systems can be considered for any application where data, video, voice, or control communications are required. Fiber optic systems are particularly advantageous when high capacity, room for growth, security, and immunity to outside interference are needed.

SUMMARY

- Light propagates along an electrical fiber in the form of light rays or modes.
- The fiber used in fiber optics consists of a core, cladding, and a plastic coating or jacket. Sometimes a layer of kevlar fibers is included between the cladding and the jacket.
- Fiber optic cable can be classified as multimode, enhanced multimode, and single-mode. Enhanced multimode has a larger core and is used in pair gain systems. Single-mode is used in very high capacity systems.
- A typical fiber optic system consists of an electrical input signal, an electrical-to-optical transducer (light source), a transmission medium (fiber), an optical-to-electrical transducer (photodetector), and an electrical output signal.

Glossary
Module 1: Transmission Technology
Pretest Training

Amplifier. An electrical device which strengthens a telephone signal. Amplifiers are used in telephone transmission because analog signals weaken as they travel and encounter resistance.

Amps. An abbreviated form of "Ampere", a measure of electrical current. It is mathematically equal to watts divided by volts.

Baseband signaling. Transmission of an analog or digital signal at its original frequencies, i.e., in its original form without change.

Broadband. Transmission facility that has a bandwidth (capacity) greater than that necessary for voice transmission. Coaxial cable is a broadband transmission facility with the capacity to carry numerous voice, video and data channels simultaneously.

Cable. Refers to a group of wires capable of carrying voice or data transmissions.

Capacitance. The capacity of a medium, such as copper wire, to store an electrical charge.

Carrier system. A system where several different signals can be combined into one carrier by changing some feature of the signals, transmitting them (modulation), and then converting the signals back to their original form (demodulation).

CATV Community Antenna Television or Cable Television. It generally uses a 75-ohm coaxial cable which simultaneously carries many frequency divided TV channels.

Circuit. The physical connection (or path) between two given points, through which an electric current may be established.

Cladding. Welding of one substance over another. Cladding is used in fiber optics where one form of fiber surrounds the center core. That surrounding is called cladding.

Coaxial cable. A cable composed of an insulated central conducting wire wrapped in another cylindrical conducting wire. The whole thing is usually wrapped in another insulating layer and an outer protective layer. A coaxial cable has great capacity to carry great quantities of information. It is typically used to carry high-speed data (as in connections of 327X terminals to computer hosts) and in CATV (multiplexed TV stations).

Conductors. Any substance, usually a wire or cable, that can carry (i.e. offer a relatively small opposition to the passage of) an electrical current.

Decibel. One tenth of a bel; the unit of measure of loudness of sounds to normal human ears; because the power of the ear to distinguish differences in loudness decreases as volume increases, the bel scale is made logarithmic; each unit is 10 times the preceding one.

Demultiplexer. A device that pulls several streams of data out of a bigger, fatter or faster stream of data.

Diaphragm. The thin flexible sheet which vibrates in response to sound waves (as in a microphone) or in response to electrical signals (as in a speaker or the receiver of telephone handset).

Dielectric. A nonconducting or insulating substance which resists passage of electric current, allowing electrostatic induction to act across it, as in the insulating medium between the plates of a condenser. Also an insulating material otherwise used (e.g. a Bakelite panel, or the cambric covering of a wire is a dielectric material).

Electromagnet. A core of magnetic material surrounded by a coil of wire through which an electric current is passed to magnetize the core.

Electromagnetic Interference (EMI). The interference in signal transmission or reception caused by the radiation of electrical and magnetic fields.

Electromagnetic isolation. A characteristic of optical fiber that makes it not vulnerable to interference, impulse noise, or crosstalk.

Electron. A particle or charge of negative electricity

Enhanced multimode fiber. An optical fiber with a large core designed to carry multiple signals distinguished by frequency or phase at the same time. Used in pair gain systems. Also known as "Fat Fiber".

Fat fiber. See Enhanced multimode fiber.

Fiber optic cable. Glass fiber for carrying lightwave communications.

Frequency Division Multiplexing. A technique in which the available transmission bandwidth of a circuit is divided by frequency into narrower bands, each used for a separate voice or data transmission channel.

Graded-index fibers. A multimode fiber optic cable that is made with progressively lower refractive index fiber toward the outer core. This reduces dispersion, which is fiber's equivalent of fading.

Impedance Matching. The connection of additional impedance to existing impedance done in order to improve the performance of an electrical circuit. Impedance Matching is done to minimize distortion, especially to data circuits.

Impedance. The total opposition a circuit offers to the flow of current. Low impedance will provide reduction in the severity of noise and other problems.

Index of refraction. A ratio of the velocity of light in a vacuum to the velocity of light in another medium, like glass.

Inductance. The property of an electric force field built up around a conductor. Inductance allows a circuit to store up electrical energy in electromagnetic form.

Infrared spectrum. Lying outside the visible spectrum at its red end. Thermal radiation of wavelengths longer than those of visible light.

Kevlar. Material used to make bullet-proof vests.

Light Emitting Diodes (LEDs). A semiconductor diode which emits light when a current is passed through it.

Local Area Networks (LANS). A data communications network spanning a limited geographical area. It provides communications between computers and peripherals, some switching to direct messages.

Local loop. The physical wires that run from the subscriber's telephone set, or PBX or key telephone system, to the telephone company central office.

Main Power Board. One of three components of the DC Distribution System. Provides protection, control functions and distributes DC power.

Megabit. One million bits.

Micrometer. Used for measuring minute distances.

Microwave radio. Transmits frequencies in the electromagnetic spectrum above one billing hertz (1 gigahertz)

Milliwatt. One thousandth of a WATT. Used as a reference point for signal levels at a given point in a circuit.

Multimode fiber. An optical fiber designed to carry multiple signals distinguished by frequency or phase at the same time.

Nanometer. One-billionth of a meter. Written nm.

Ohms. The practical unit of resistance. The resistance that will allow one-ampere of current to pass at the electrical potential of one volt.

Optical fiber. Glass fiber for carrying lightwave communications.

Parallel Circuit. An electrical circuit that contains one or more points where the current divides and follows different paths.

Photodetector. In a lightwave system, a device which turns pulses of light into bursts of electricity.

Radio frequency interference (RFI). The disruption of radio signal reception caused by any source which generates radio waves at the same frequency and along the same path as the desired wave.

Regenerator. A device used to restore a signal to its original shape.

Repeater. A device inserted at intervals along a circuit to boost, and amplify an analog signal being transmitted.

Resistance. Generates heat and occasionally light. A property or characteristic of a conductor, i.e. the metal through which the electricity flows.

Ring. One of the two wires (Tip and Ring) needed to set up a telephone connection. Usually connected to the negative side of a battery at the central office.

Series Circuit. An electrical circuit with a single path for electron flow from source to load and back.

Shielding. The metal-backed mylar, plastic, teflon or PVC that protects a data-communications medium such as coaxial cable from Electromagnetic Interface and Radio Frequency Interference.

Singlemode fiber. An optical waveguide which is constructed to propagate (i.e. carry) only the single wavelength selected for transmission.

Step-index process. A type of optical fiber with a uniform index of refraction throughout the core.

Subscriber Loop Carrier (SLC) system. A short haul multiplexing device which enables up to 96 telephone customers to be served on three pairs of wires.

T-Carrier systems. A time-division multiplexed, phone company-supplied, digital transmission facility operating at an aggregate data rate of 1.544 Mbit/s.

Terminals. The screws or soldering lugs to which an external circuit can be connected.

Tip. One of two wires (Tip and Ring) needed to set up a telephone connection. Usually connected to the positive side of a battery at the central office.

Transducer. A device which converts one form of energy into another. The diaphragm in the telephone receiver and the carbon microphone in the transmitter are transducers.

Unshielded Twisted Pair (UTP). A cable medium with one or more pairs of twisted insulated copper conductors bound in a single plastic sheath.

Visible spectrum. The range of colors that can be seen by the naked eye. The spectrum is basically from red to yellow and orange (roughly the 5770 to 7700 angstrom range) and from green to violet-black (approximately the 3900 to 5770 angstrom range).

Waveform. The characteristic shape of a period signal usually shown as a plot of amplitude over a period of time.

Technician Minicourse
PRETEST TRAINING

MODULE 1:
Transmission Technology

TIMED PRACTICE TEST

The test that follows has 30 questions. You will have 15 minutes to complete.

1. Which of the following is a basic part of a transmission system?
   a. LED
   b. pulse regenerater
   c. analog wave form
   d. source of energy

2. The longest transmission line can be
   a. Several hundred feet
   b. Several hundred yards
   c. Several miles
   d. Several thousand miles

3. Which of the following is an example of an analog wave form?
   a. Sine wave
   b. Pulse wave
   c. LED wave
   d. All of the above

4. The device that translates electricity into sound waves in a telephone receiver is which of the following:
   a. Electromagnet
   b. Carbon granules
   c. Diaphragm
   d. none of the above

5. Which of the following is considered a transmission medium?
   a. Paired cable
   b. optical glass fiber
   c. Microwave radio
   d. All of the above

6. The final reproduction of a voice signal enters a listener's ear in the form of:
   a. Electromagnetic waves
   b. Air pressure
   c. Electrical signals
   d. modulated pulses

7. Amplifiers are used to control which of the following problems?
   a. Noise
   b. Distortion
   c. Interference
   d. attenuation

8. Which of the following is a source of noise in an analog transmission line?
   a. Lightning
   b. Power lines
   c. radio transmitters
   d. all of the above

9. Which of the following is a method for preventing crosstalk?
   a. Frequency division multiplexing
   b. Amplification
   c. regeneration
   d. longer transmission systems

10. Digital transmission converts signals into which of the following?
    a. analog wave forms
    b. sine waves
    c. a series of electrical pulses
    d. air pressure

11. Which of the following is true of digital signals?
    a. they are easier to multiplex
    b. They cost more than analog
    c. they carry more noise
    d. all of the above

12. Copper wire is twisted into pairs so that which of the following will occur?
    a. the signal will not be weakened by capacitance
    b. the signal will not be weakened by electrical interference
    c. noise will be reduced
    d. distortion will be reduced

13. Putting a shield around twisted pair will result in which of the following?
    a. the signal will not be weakened by capacitance
    b. the signal will not be weakened by electrical interference
    c. noise will be reduced
    d. distortion will be reduced

14. Which of the following is part of the central loop?
    a. the tip
    b. the ring
    c. the central office
    d. all of the above

15. What is the best transmission medium for small networks linking personal computers?
    a. untwisted pair
    b. fiber optic cable
    c. coaxial cable
    d. twisted pair

16. Which of the following can reduce the vulnerability of twisted pair to noise?
    a. multiplexing and demultiplexing
    b. shielding and repeating
    c. regeneration and dispersion
    d. amplification and de-amplification

17. The center conductor in a coaxial cable is made of which of the following?
    a. Kevlar
    b. copper
    c. dielectric
    d. optical fiber

18. Which type of cable is standard for CATV systems?
    a. twisted pair
    b. 50 ohm cable
    c. 75 ohm cable
    d. optical fiber

19. A milliwatt is which of the following:
    a. one tenth of a watt
    b. one hundredth of a watt
    c. one thousandth of a watt
    d. one millionth of a watt

20. A gain in a transmission line would be signified by which of the following?
    a. 1Kbps
    b. +Kbps
    c. +dB
    d. -dB

21. Which of the following constitutes the innermost layer of optical fiber cable?
    a. very thin glass or plastic
    b. cladding
    c. jacket
    d. kevlar

22. Which of the following constitutes makes up the middle layer of optical fiber cable?
    a. very thin glass or plastic
    b. cladding
    c. jacket
    d. kevlar

23. Which of the following constitutes makes up the outermost layer of optical fiber cable?
    a. very thin glass or plastic
    b. cladding
    c. jacket
    d. kevlar

24. The two basic types of optical fibers used in the telephone business are:
    a. multimode and singlemode
    b. multiplex and demultiplex
    c. twisted and untwisted pair
    d. coaxial and axial

25. Modal dispersion results in which of the following?
    a. increases noise in the system
    b. shortens the required distance between regeneration points
    c. lengthens the required distance between regeneration points
    d. speeds up the signal

26. Graded-index fibers have which of the following advantages over step-index fibers?
    a. allow regenerators to be placed farther apart
    b. decrease noise in the system
    c. strengthens the signal
    d. speeds up the signal

ANSWER SHEET

Record your answers to the test questions by circling your answer choices on this page.
You will have *15 minutes* to complete this portion of the test.

1)	a	b	c	d	16)	a	b	c	d
2)	a	b	c	d	17)	a	b	c	d
3)	a	b	c	d	18)	a	b	c	d
4)	a	b	c	d	19)	a	b	c	d
5)	a	b	c	d	20)	a	b	c	d
6)	a	b	c	d	21)	a	b	c	d
7)	a	b	c	d	22)	a	b	c	d
8)	a	b	c	d	23)	a	b	c	d
9)	a	b	c	d	24)	a	b	c	d
10)	a	b	c	d	25)	a	b	c	d
11)	a	b	c	d	26)	a	b	c	d
12)	a	b	c	d	27)	a	b	c	d
13)	a	b	c	d	28)	a	b	c	d
14)	a	b	c	d	29)	a	b	c	d
15)	a	b	c	d	30)	a	b	c	d

Technician Minicourse

PRETEST TRAINING

MODULE 1:

Transmission Technology

ANSWERS

to

TIMED PRACTICE TEST

1. Which of the following is a basic part of a transmission system?
   Correct answer = **d. source of energy**.
   (p. 13) A transmission system consists of three parts:
   - **source of energy**
   - line over which to send that energy
   - receiving device

2. The longest transmission line can be
   Correct answer = **D. Several thousand miles**
   (p. 13) The transmission line can be as short as a few feet or as long as **several thousand miles**, and can be made of paired cable, coaxial cable, microwave radio, or optical glass fiber.

3. Which of the following is an example of an analog wave form?
   Correct answer = **A. Sine wave**
   (p. 13) Electronic signals are generated in a variety of forms such as **sine waves**, voice waves, etc.

4. The device that translates electricity into sound waves in a telephone receiver is which of the following:
   Correct answer = **A. Electromagnet**
   (p. 14) In the receiver, this alternating current is translated by an **electromagnet** back into sound waves.

5. Which of the following is considered a transmission medium?
   Correct answer = **D. All of the above**
   (p. 13) The transmission line can be as short as a few feet or as long as several thousand miles, and can be made of **paired cable, coaxial cable, microwave radio, or optical glass fiber**.

6. The final reproduction of a voice signal enters a listener's ear in the form of:
   Correct Answer = **B. Air pressure**
   (p. 14) ...an exact reproduction of the original signal enters the telephone receiver and converts to **air pressure** in the ear of the listener.

7. Amplifiers are used to control which of the following problems?
   Correct answer = **D. attenuation**
   (p. 15) **Loss** can be overcome by using an **amplifier** to restore the signal to its original amplitude.

8. Which of the following is a source of noise in an analog transmission line?
   Correct answer = **D. all of the above**
   (p. 15) In transmission lines, noise comes from electrical influences such as power lines, lightning, commercial radio transmitters, and crosstalk between lines

9. Which of the following is a method for preventing crosstalk?
   Correct answer = **A. Frequency division multiplexing**
   (p. 15) In **FDM**, multiple voice channels are combined into a single signal which is carried over a link thus making the most efficient use of that link. Each low-speed voice channel is modulated on a separate frequency within the bandwidth of the line, thus keeping the channels apart and preventing **crosstalk.**

10. Digital transmission converts signals into which of the following?
    Correct answer = **C. a series of electrical pulses**
    (p. 15) *Digital transmission* is a means to transmit analog signals (voice) by converting the signals to a **series of electrical pulses.**

11. Which of the following is true of digital signals?
    Correct answer = **A. they are easier to multiplex**
    (p. 16) There are several very important reasons for using digital transmission. They are:
    - lower cost than analog
    - free from distortion and noise
    - **easier to multiplex (mix) with other signals**

12. Copper wire is twisted into pairs so that which of the following will occur?
    Correct answer = **A. the signal will not be weakened by capacitance**
    (p. 17) The **two wires are twisted together to reduce capacitance that can build up between the wires and weaken the signal.**

13. Putting a shield around twisted pair will result in which of the following?
    Correct answer = **C. noise will be reduced**
    (p. 17) **Noise can be prevented** by putting a shield around the twisted pair...

14. Which of the following is part of the central loop?
    Correct answer - **D. all of the above**
    (p. 17) The **tip and ring** are the transmit and receive lines for the signal. Together with the **Central Office (CO)** and the customer premises, **they make up the local loop.**

15. What is the best transmission medium for small networks linking personal computers?
    Correct answer = **D. twisted pair**
    (p. 17-18) **Twisted pair** wire is best for low-cost, short-distance LANS, especially for small networks linking personal computers.

16. Which of the following can reduce the vulnerability of twisted pair to noise?
    Correct answer = **B. shielding and repeating**
    (p. 18) Two techniques can reduce the vulnerability of twisted pair to noise: **shielding and repeating.**

17. The center conductor in a coaxial cable is made of which of the following?
    Correct answer = **B. copper**
    (p. 18) All forms of coaxial cable are comprised of a center conductor made of **copper** that carries the signal

18. Which type of cable is standard for CATV systems?
    Correct answer = **C. 75 ohm cable**
    (p. 18) There are two types of coaxial cable currently in use for LAN (Local Area Network) applications: **75-ohm cable, which is the standard used in community antenna television (CATV) systems**, and 50-ohm cable.

19. A milliwatt is which of the following:
    Correct answer = **C. one thousandth of a watt**
    (p. 19) Power is the product of current and voltage and the unit used is the watt or, more appropriately for telecommunications, the *milliwatt* which equals **one-thousandth of a watt.**

20. A gain in a transmission line would be signified by which of the following?
    Correct answer = **C. +dB**
    (p. 19) In normal practice, **gains are shown as +dB**

21. Which of the following constitutes the innermost layer of optical fiber cable?
    Correct answer = **A. very thin glass or plastic**
    (p. 22) The *core* is the innermost section and consists of a **very thin glass or plastic** strand (or fiber). The core is typically from about 8 to 62.5 μm (micrometer) in diameter.

22. Which of the following constitutes the middle layer of optical fiber cable?
    Correct answer = **B. cladding**
    (p. 22) The **core is surrounded by the *cladding*,** a glass or plastic coating with a typical outside diameter of 125 μm.

23. Which of the following constitutes the outermost layer of optical fiber cable?
    Correct answer = **C. jacket**
    (p. 22) The outermost layer is the **jacket**

24. The two basic types of optical fibers used in the telephone business are:
    Correct answer = **A. multimode and singlemode**
    (p. 22) There are two basic types of optical fibers used in the telephone business today: **singlemode** fibers used in very high capacity systems, and **multimode** fibers

25. Modal dispersion results in which of the following?
    Correct answer = **B. shortens the required distance between regeneration points**
    (p. 23) This condition, called *modal dispersion,* **shortens the required distance between regeneration points**

26. Graded-index fibers have which of the following advantages over step-index fibers?
    Correct answer = **A. allow regenerators to be placed farther apart**
    (p. 23) Multimode fibers are now manufactured as *graded-index fibers,* which improves the poor transmission characteristics of step index fibers. The index of refraction is lower in the outer rings and becomes progressively higher toward the center. The center of the core will possess the highest refractive index. This will cause those modes that propagate down the center (shorter path) of the fiber core to travel at slightly lower speeds than those that take the longer paths. This controls the propagation velocity so that all modes arrive at the receive end of the fiber at virtually the same time, thus **allowing regenerators to be spaced further apart.**

27. Which of the following is a disadvantage of fiber optic cable?
    Correct answer = **B. fiber optic cable is more expensive than copper**
    (p. 26) There are a few disadvantages to fiber. It is still somewhat **more expensive** than cable

28. Electricity was discovered
    Correct answer = **B. About 2,500 years ago by the Greeks**
    (p. 4) The **Greeks discovered electricity about 2,500 years ago.**

29. Alternating current has which of the following advantages over DC current
    Correct answer = **C. it can be transformed more easily**
    (p. 5) It is **easy to transform alternating current** whereas Direct Current cannot be transformed.

30. Which of the following generates DC current?
    Correct answer = **d. all of the above**
    (p. 6) DC power sources are: generators, rectifiers, converters and batteries.

Technician Minicourse

PRETEST TRAINING

MODULE 2:

Understanding Technical Documents and Troubleshooting Circuits

STUDY MATERIAL

Understanding Technical Documents

This module consists of two Parts.

- Part 1 — Understanding Technical Documents is designed to familiarize you with some of the basic concepts and functions involving technical documentation that are used in the work of technicians. The Work Order Referral Document (WORK) Request as it is used in this lesson is a generic document that combines elements of some of the existing systems used to communicate information to telecommunications technicians.
- Part 2 — Troubleshooting introduces a process for locating and eliminating sources of problems in a logical and prescribed manner.

The material and references in this lesson are not actually used in any of the systems currently in place at Bell Atlantic so you should not assume that material that you might have learned in the past will apply. **Therefore, in reading this lesson, you should rely only on the material provided in this document and appendix.**

This review covers the same type of materials as the minicourse as well as provides a practice test.

Learning Objectives — When you have completed this module you will be able to :

- State the general purpose of a Work Request
- Name each of the 3 sections of a WORK Request and describe the functions of each section
- Locate information from Customer Information, Circuit Specification, and Work Authorization Sections of the document
- Analyze symptoms and generate a list of possible causes
- Arrange list of causes in a logical order
- Use the process to rule out possibilities and test probable causes
- Remedy the problem

Practice Test

The practice test is provided to support your learning of this module and to provide practice in test taking. The time test will contain 32 questions and you should give yourself 30minutes to complete the test. These are similar to the conditions you will encounter when you take the required knowledge test after the minicourse.

Technical Reading Telecommunications Technology Course

We also refer you to the Technical Reading Telecommunications Technology course. The following Books and Lessons will familiarize you with structure technical information formats and provide you with some strategies for understanding and assimilating information

BOOK	LESSON
Book 7: Structured Information	Lesson 1: Introduction to Structured Information

Part 1

Understanding Technical Documents

The Work Order Referral Document (WORK) Request as it is used in this module is a generic document that combines elements of some of the existing systems used to communicate information to telecommunications technicians. The material and the references in this module are not actually used in any of the systems currently in place at Bell Atlantic so you should not assume that material that you might have learned in the past will apply. **Therefore, in reading this module you should rely only on the material provided in this document and the appendix.**

The material in this module is designed to familiarize you with some of the basic concepts and functions involving technical documentation that are used in the work of technicians. Documents, such as the WORK Requests described in this module are valuable tools that contain all the important source information necessary to enable you to complete and record your work assignments. The first part of this module will acquaint you with the more significant information found in a WORK Request.

Objectives:

Upon completion of Part 1, you will be able to:

1. State the general purpose of a WORK Request.

2. Name each of the three sections of a WORK Request and describe the functions of each section.

3. Locate from the customer information section of the document, such as:
   - customer name
   - customer location
   - prior telephone number
   - billing telephone number
   - terminal code

4. Locate from the circuit specifications section of the document, such as:
   - Wire Location
   - Wire Design Number
   - Wire Specification Number

5. Locate information from the work authorization section of the document, such as:

- Loop Facilities Assignment and Control System Number

History

The installation and maintenance of circuits begins with the receipt of an official authorization document. Over the years, a variety of documents were used for this purpose. Even though they had different names and looked different, these documents all served the same purpose. One such document is the WORK (Work Order Request Referral Document) Request. In the near future, almost all circuit work orders will be computer generated and distributed automatically via a WORK Request.

The WORK Request is composed of 3 distinct sections, each with a specific purpose:

- Customer Information (CI)
- Circuit Specifications (CS)
- Work Authorization (WA)

Section 1: Customer Information - CI

The first portion of the WORK Request is the customer information section (gray shaded area). This section provides the technician with necessary information about the customer, type of available service options and other customer information depending on the document. Refer to diagram 1.1 below and the Code List in Appendix A.

WORK Request 1.1

	C.I.	
CN Boone	**CL** south cen	**APC** 578-0596
ATM - NO	**BOSS** - 11	**CAP** SP
PTN 788-5902	**BTN** 204-532-5672	**TC**- 762-9804
	C.S.	
WTL cast ccn	**LCL** 203	**WDN** 219
ORd-9/21/xx	**WLO** west cen	**SST** 102
ACS 245	**LSP** CO-2	**WSN**- 197
	W.A.	
RN- 2162	**ONA** NO	**NPO** 1520
CCSA YES	**GTI** 160	**LFACS** 121
WRD 915	**POP** 15	**WB** 2220

DIAGRAM 1.1

Each bold face code represents a specific type of information. The type of information represented by each code can be found in the Appendix. Refer to Example A. In this example, CN represents Customer Name and BTN represents the Billing Telephone Number.

Example A

CODE LISTINGS

↓ ↓

Customer Name: CN

Billing Telephone Number: BTN

In Diagram 1.1, for example, the information associated with the code for CN (customer name) is Boone.

Section 2: Circuit Specifications - CS

The second portion of the WORK Request contains information on circuit specifications. This information is useful when you need to install, test, and troubleshoot a telephone circuit. The circuit specifications section includes codes such as: wire specification number, wire design number, and other information depending on the document. Refer to diagram 1.2. The circuit specifications section is shaded gray.

WORK Request 1.2

	C.I.	
CN Boone	**CL** south cen	**APC** 578-0596
ATM - NO	**BOSS** - 11	**CAP** SP
PTN 788-5902	**BTN** 204-532-5672	**TC-** 762-9804
	C.S.	
WTL east cen	**LCL** 203	**WDN** 219
ORd-9/21/xx	**WLO** west cen	**SST** 102
ACS 245	**LSP** CO-2	**WSN-** 197
	W.A.	
RN- 2162	**ONA** NO	**NPO** 1520
CCSA YES	**GTI** 160	**LFACS** 121
WRD 915	**POP** 15	**WB** 2220

DIAGRAM 1.2

Section 3: Work Authorization - WA

The third portion of the WORK Request provides information on work authorization. The WA section contains information regarding the type of work to be performed for the customer. It also provides the purchase order number, LFACS number, and other information depending on the document. Refer to diagram 1.3. The work authorization section is shaded gray.

WORK Request 1.3

	C.I.	
CN Boone	**CL** south cen	**APC** 578-0596
ATM - NO	**BOSS** - 11	**CAP** SP
PTN 788-5902	**BTN** 204-532-5672	**TC-** 762-9804
	C.S.	
WTL east cen	**LCL** 203	**WDN** 219
ORd-9/21/xx	**WLO** west cen	**SST** 102
ACS 245	**LSP** CO-2	**WSN-** 197
	W.A.	
RN- 2162	**ONA** NO	**NPO** 1520
CCSA YES	**GTI** 160	**LFACS** 121
WRD 915	**POP** 15	**WB** 2220

DIAGRAM 1.3

Accessing codes to identify work authorization information follows the same straight forward method used for CI. First, look up the desired listing in the code list. Next, identify the corresponding code. Finally refer to the WORK Request for the desired information.

Part 2

Troubleshooting

In this section you will learn some general concepts of troubleshooting and then learn to apply a specific series of troubleshooting steps to a set of problems for transmission circuits using WORK documents.

The word "troubleshooting: literally means aiming at a trouble or a problem and firing away until you hit the bulls-eye. In a more practical sense, the term refers to a process for locating and eliminating sources of problems in a logical and prescribed manner. It is a process that lets you approach a problem from all angles and zero in on the cause in a way that involves the least amount of time and energy.

An analysis of the troubleshooting process reveals that it is possible to break the process down into three distinct phases or steps:

1. Analysis of symptoms and generation of possible causes
2. Arrangement of the list of causes in a logical order, with the most probable at the top
3. Using the process to rule out possibilities, test each probable cause until the problem is identified.

The need for a thorough grasp of troubleshooting techniques and procedures in today's high-tech world is underscored by the fact that troubleshooting is the basis of all electronic and mechanical repairs. Most industrial and consumer electronic devices today come with manuals that contain a troubleshooting guide.

Consider the following example. In the problem shown below, an **error message code** indicates that there is a problem and provides some information about what the problem is. In this case, the problem is improper or no power being supplied to a circuit.

ERROR MESSAGE CODE	PROBLEM
POWER	IMPROPER OR NO POWER BEING SUPPLIED TO CIRCUIT

In order to troubleshoot this problem a technician would follow a logical sequence of the following procedure

TROUBLESHOOTING SEQUENCE AND PROCEDURES

In this example, the proper sequence of procedures for troubleshooting the above problem would involve the following five steps:

1. Check for power.
2. Is the appropriate level of voltage being generated?
3. Is power supply correctly installed?
4. Are the connections to the power supply plugged in?
5. Check for blown fuse.

The five steps and the logical sequence in which they are followed can be represented in a **flowchart**. A flowchart is a graphic representation of the steps that should be followed in troubleshooting a problem. Refer to the troubleshooting chart on the following page.

Flowchart for troubleshooting Power problem

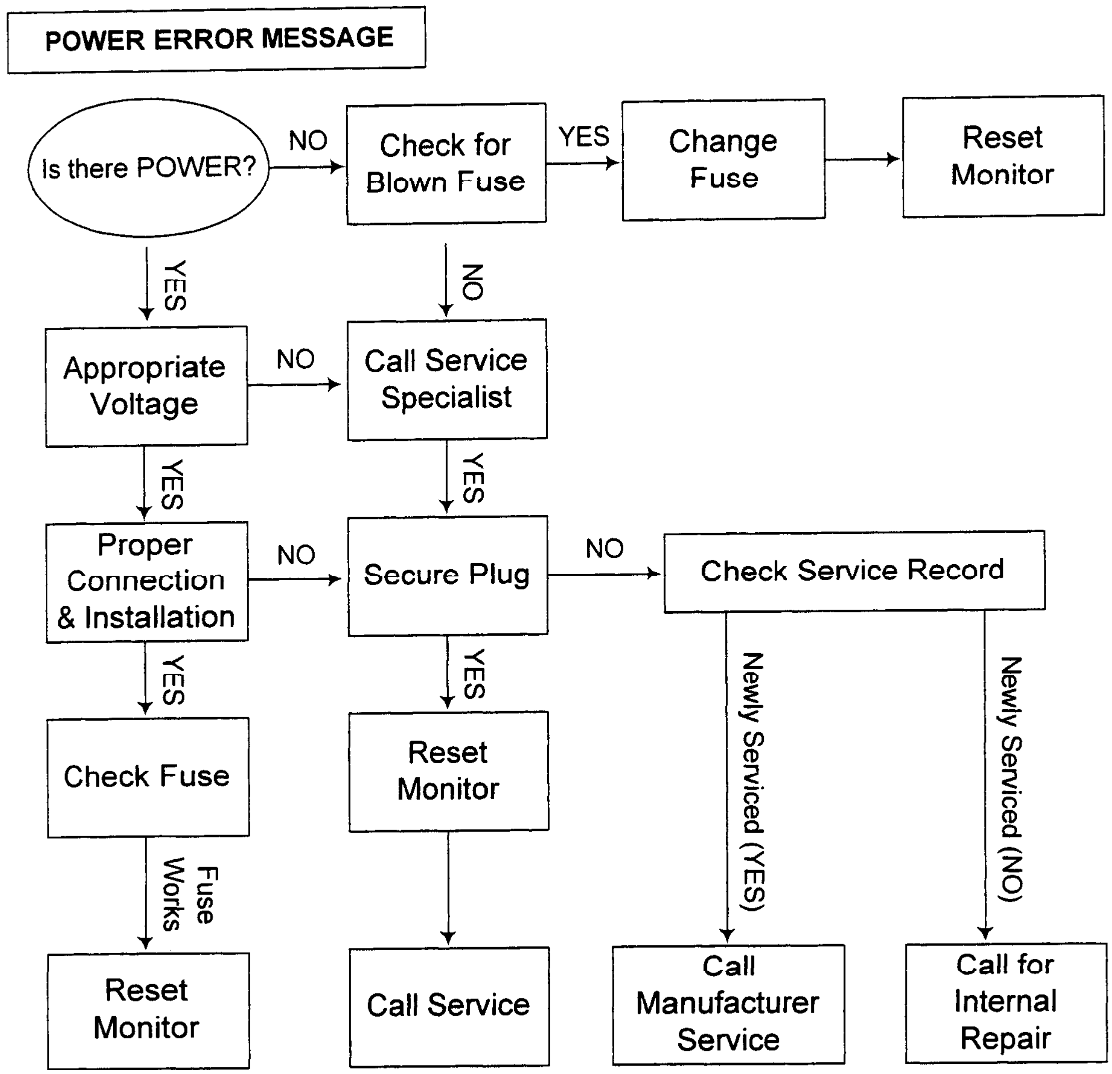

Diagram 2.1

It can be seen that at each step of the troubleshooting flowchart a check or test is done. Depending upon the outcome or results of the test a different path is followed. This sequence of activities is followed until the problem is resolved.

In Step 1 a check for power is made. If power is not present a blown fuse is checked for. The fuse should then be changed and the monitor should be reset. If power is present, then Step 2 is carried out.

In Step 2, the voltage should be checked to make sure that it is at the right level. If it is not, then a service specialist should be called.

If voltage is appropriate then Step 3 should be performed.

Note that each step is dependent upon the outcome of a previous step. By following the flowchart sequence, an individual with limited knowledge of the system can solve troubleshooting problems.

A second example is shown below. The problem or "trouble" is a communication error resulting from a poor quality phone line.

ERROR MESSAGE CODE	PROBLEM
COMM. ERROR	**You have encountered a communication error that resulted from a poor quality phone line**

In order to solve this problem a technician would follow a sequence of the following five steps.

TROUBLESHOOTING SEQUENCE AND PROCEDURES

1. Try call again.
2. Check sending unit for dial indicator for send position.
3. Check sending unit for clean contacts and connections.
4. Switch ignition switch on to sending unit, hold send button for 2 seconds, observe the red LED on panel for system ok.
5. Call service.

Each of these steps is represented in the flowchart on the following page.

Flowchart for troubleshooting Communication problem

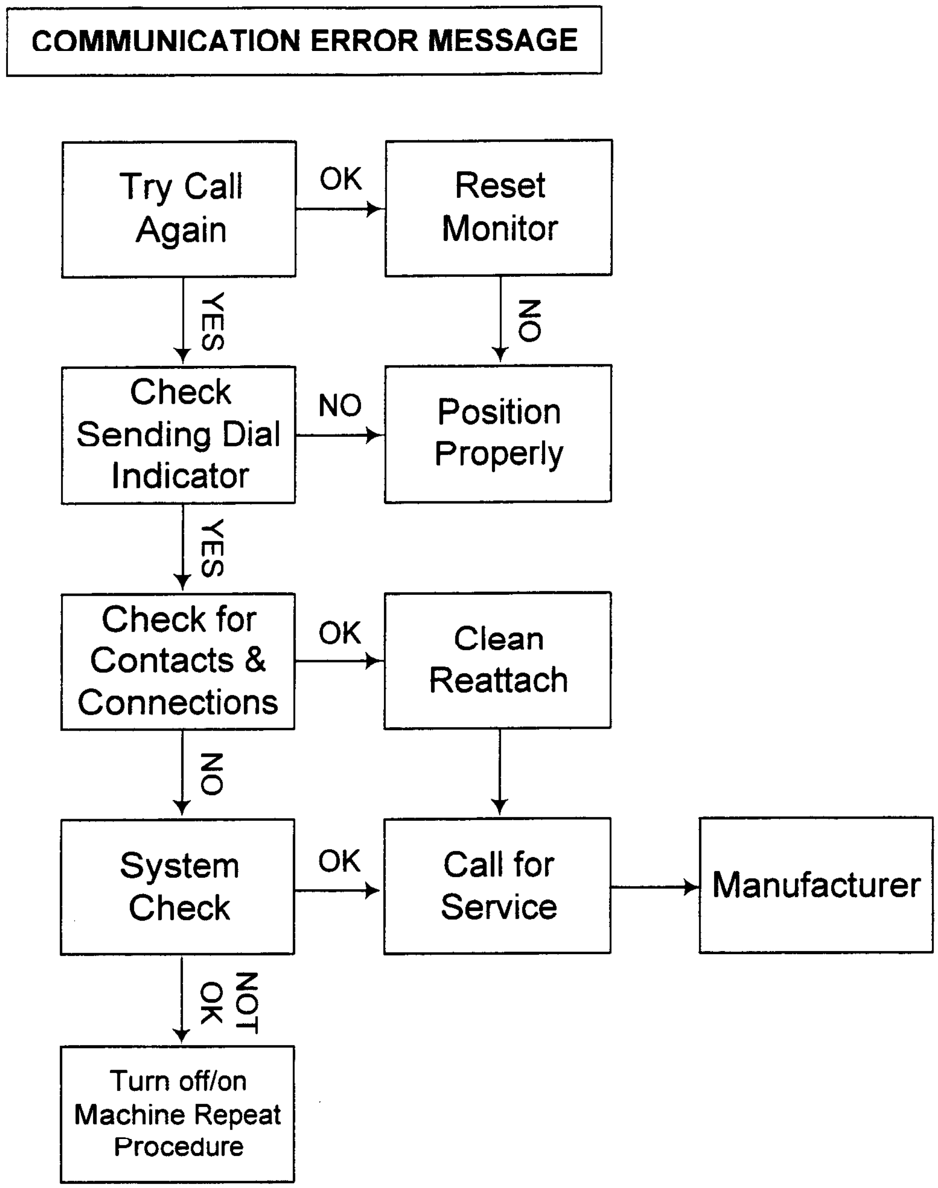

Diagram 2.2

A Troubleshooting Process

The remainder of this module is designed to familiarize you with a generic troubleshooting process for transmission circuits. The WORK Request described earlier will serve as a starting point for the troubleshooting steps. Each time a trouble report is received, specific steps should be taken. The order of the steps remains the same from one trouble situation to the next. These steps reduce the time it takes to find and correct the trouble.

Objectives

Upon the completion of this section, you will able to:

1. Name the main steps in the troubleshooting process.
2. Identify the correct order of steps.
3. Explain the purpose of each step.
4. Identify, isolate, locate the trouble.
5. Follow guidelines and procedures for decision making.
6. Remedy the problem.

Troubleshooting WORK Request

You will now learn how to troubleshoot problems in transmission circuits from information retrieved from the WORK Request. To do this, you must locate the WORK code that indicates trouble in the circuit. Then you must refer to a flowchart to identify which problem is in the circuit. You must then find the correct path to remedy the problem.

Steps for Troubleshooting Circuits

Step 1. Locate the Loop Facility Assignment and Control Number and the Wire Specification number.

Refer to the listings in Appendix A to identify the code for Loop Facility Assignment Control System number and the Wire Specification number. Locate the Loop Facilities Assignment Control System number and the Wire Specification number. Refer to Example B. The Wire Specification number uses the **WSN** designation. Now refer to the WORK Request on the next page for the desired information. The Loop Facilities Assignment Control System uses the designation **LFACS**.

Example B

CODE LISTINGS

Loop Facilities Assignment and Control System Number: LFACS

Wire Specification Number: WSN

For this example, the LFACS number is 649 and the Wire Specification number is 201.

WORK Request 2.3

	C.I.	
CN Smith	**CL** north cen	**APC** 337-3358
WATS - No	**BTN** 210-231-2332	**ATM** - Yes
PTN 691-7575	**CALL C** - No	**C-** 210-5969
	C.S.	
WLO east cen	**LSP** - East	**WDN** 209
ORd--11/23/xx	**WTL** west cen	**SST** 1129
WSN-201 (Step 2)	**NOS** - 2278	**ACS** - 464
	W.A.	
RN- 1009	**TCP/IP** - In Use	**NPO** 1160
POP - None	**GTI** 160	**WB** - 2026
WRD 1129	**WATS** - South	LFACS-649 (Step 2)

DIAGRAM 2.3

Step 2. Compare the two numbers.

If the LFACS number is higher than the Wire Specification number, find the **Wideband number** (See Appendix for Code) to get the diagnostic test results.
If the Wire Specification number is higher than the LFACS number, find the **Purchase order number** (See Appendix for Code) to get the diagnostic test results.

Refer to diagram 2.3 above. The LFACS number is higher than the Wire Specification number. The correct designation to refer to in this example is the **Wideband**: **WB.** The test results indicate a value of **2026** for this example.

Step 3. Identify the appropriate troubleshooting flowchart.

Refer to Section B in the Appendix.
Once you have identified the appropriate test results (Wideband or Purchase Order Number) and retrieved that number from the WORK Request, you may now compare that number with the values in the top right hand page to identify the correct troubleshooting flowchart. Refer to flowchart 4 in the Appendix. The Wideband test results fall between 2021-2030 so Flowchart 4 is the correct flowchart.

Step 4. Determine which path on the flowchart to follow.

Identify which range of values the test results fall between within this initial flowchart. Using Flowchart 4 in the Appendix, find the path by using the test results found in the previous step. Since the Wideband results are 2026 the correct path in Flowchart 4 is Path 2.

Step 5. Identify the appropriate corrective action flowchart.

Follow the arrows of the appropriate flowchart path right to identify the appropriate corrective action flowchart. The proper corrective flowchart is: **Flowchart 7.**

Step 6. Find the Wire Location.

You must now refer back to the WORK Request to determine the wire location. In the example below (diagram 2.4), the wire location **(WLO)** is **East Central**. The thick black arrow **(labeled step 6)** points to where this information can be obtained.

WORK Request 2.4

	C.I.	
CN Smith	**CL** north cen	**APC** 337-3358
WATS - No	**BTN** 210-231-2332	**ATM** - Yes
PTN 691-7575	**CALL C** - No	**C-** 210-5969
	C.S.	
WLO east cen	**LSP** - East	**WDN** 209
ORd--23/xx	**WTL** west cen	**SST** 1129
WSN-201	**NOS** - 2278	**ACS** - 464
STEP 6	**W.A.**	
RN- 1009	**TCP/IP** - In Use	**NPO** 1160
POP - None	**GTI** 160	**WB** - 2026
WRD 1129	**WATS** - South	**LFACS**-649

DIAGRAM 2.4

Step 7. Determine which path on the corrective action flowchart to follow.

Now that you have obtained the needed wire location, look at the corrective action flowchart (Flowchart 7) from Section B in the Appendix to identify the correct path to follow. Since East Central is the Wire Location, **Path 3: East Central** is the appropriate path.

Step 8. Obtain the wire design number.

In order to use Flowchart 7 you must have the Wire Design Number. Refer to diagram 2.5 below. The thick black arrow **(labeled step 8)** points to where
to obtain the wire design number. In this example, the number is **WDN=209**.

WORK Request 2.5

	C.I.	
CN Smith	**CL** north cen	**APC** 337-3358
WATS - No	**BTN** 210-231-2332	**ATM** - Yes
PTN 691-7575	**CALL C** - No	**C-** 210-5969
	C.S.	
WLO east cen	**LSP** - East	**WDN** 209
ORd--11/23/xx	**WTL** west cen	SST 1129
WSN-201	**NOS** - 2278	**ACS** - 464
	W.A.	
RN- 1009	**TCP/IP** - In Use	**NPO** 1160
POP - None	**GTI** 160	**WB** - 2026
WRD 1129	**WATS** - South	**LFACS**-649

STEP 9

DIAGRAM 2.5

Step 9. Determine which sub-path to follow.

If the wire design number is **199 and below**, follow the upper route of the path. If the wire design number is **200 and above**, follow the lower route of the path. In this example the **WDN= 209**, therefore follow the **lower route** of Path 3. Refer back to Flowchart 7 above from Section B, in the Appendix.

Step 10. Identify the appropriate corrective action to take.

Follow the lower route of Path 3 to the corrective action. The proper corrective action contained in the right most column is **Select Cable Config. B.**

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MODULE 2:
Understanding Technical Documents and Troubleshooting Circuits

Appendix

APPENDIX **Section A**

CODE LISTINGS

1. **<u>Alarm Protection Code: APC</u>**
2. **<u>Asynchronous Transfer Mode: ATM</u>**
3. **<u>Area Code: AC</u>**
4. **<u>Band Rate: BR</u>**
5. **<u>Bell Operating Company: BOC</u>**
6. **<u>Billing and Order System Support: Boss</u>**
7. **<u>Billing Telephone Number: BTN</u>**
8. **<u>Business Process Reengineering: BPR</u>**
9. **<u>Call Collection: Call C</u>**
10. **<u>Cellular Wireless Services: CWS</u>**
11. **<u>Circuit Switching Access: ACS</u>**
12. **<u>Common Control Switching Arrangement: CCSA</u>**
13. **<u>Competitive Access Provider: CAP</u>**
14. **<u>Customer Location: CL</u>**
15. **<u>Customer Name: CN</u>**
16. **<u>Data Terminal Equipment: CTE</u>**
17. **<u>Digital Access and Cross-Connect: DACS</u>**
18. **<u>Digital Channel Service: DCS</u>**
19. **<u>Electronic Switching Systems: ESS</u>**
20. **<u>Fiber Distributed Data Interface: FDDI</u>**

21. **Frame Relay: FR**

22. **Geographic Test Index: GTI**

23. **Integrated Services Digital Network: ISDN**

24. **Loop Customer Line: LCL**

25. **Loop Facility Assignment and Control System Number: LFACS**

26. **Message Rate Service: MRS**

27. **Network Operating System: NOS**

28. **Open Network Architecture: ONA**

29. **Order Request Date: ORd**

30. **Point of Presence: POP**

31. **Prior Telephone Number**

32. **Purchase Order Number: NPO**

33. **Request Number: RN**

34. **Special Services Test Number: SST**

35. **Switching Point Location: LSP**

36. **Terminal Code: TC**

37. **Terminal Service Number: TSN**

38. **Transmission Control Protocol/Internet Protocol: TCP/IP**

39. **Voice Digitization: VD**

40. **Wide Area Telecommunication Service: WATS**

41. **Wideband: WB**

42. **Wire Design Number: WDN**

43. **Wire Location: WLO**

44. <u>Wire Request Number: WRD</u>

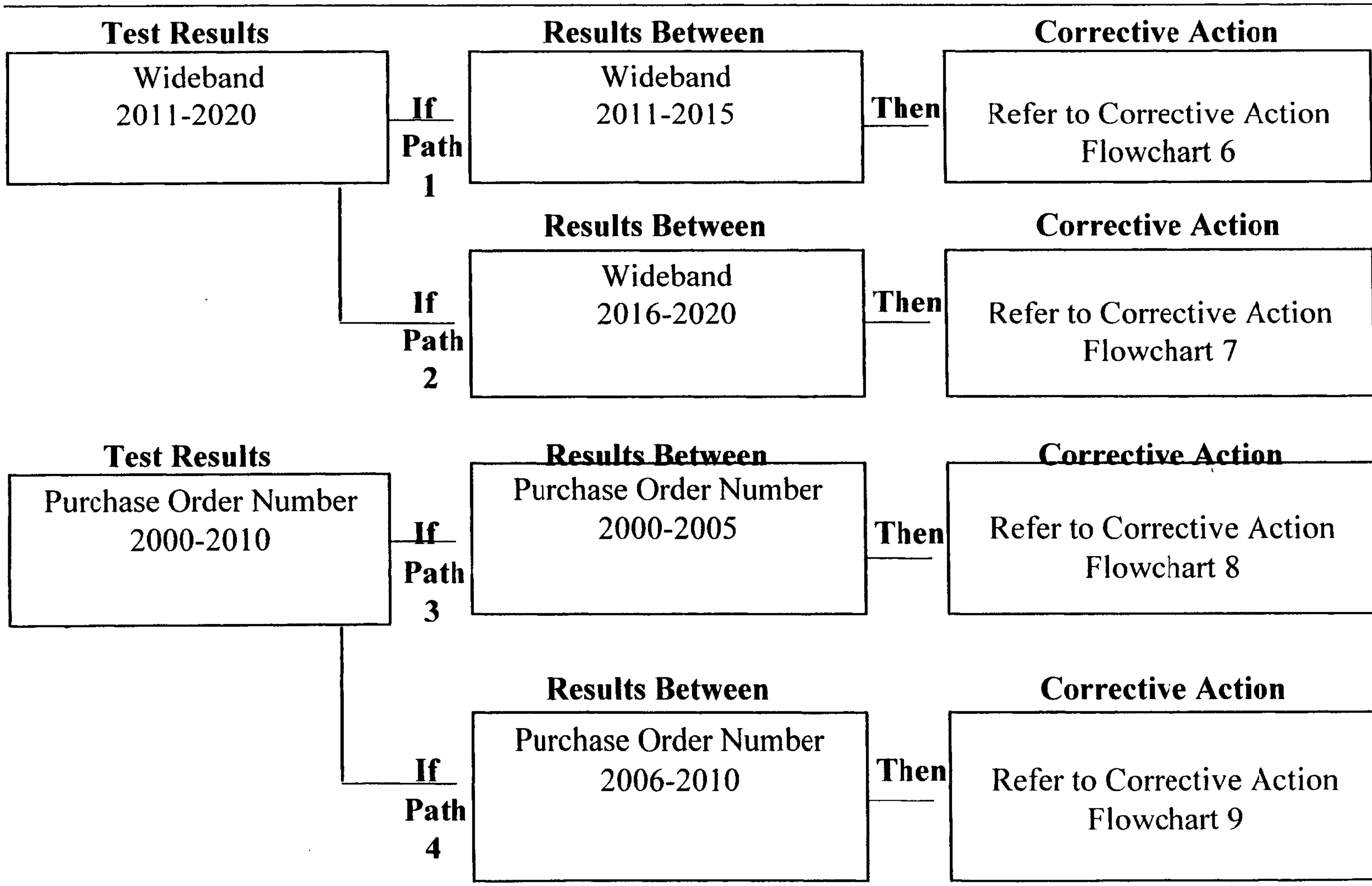
45. <u>Wire Specification Number: WSN</u>

46. <u>Wire Termination Location: WTL</u>

Appendix Section B

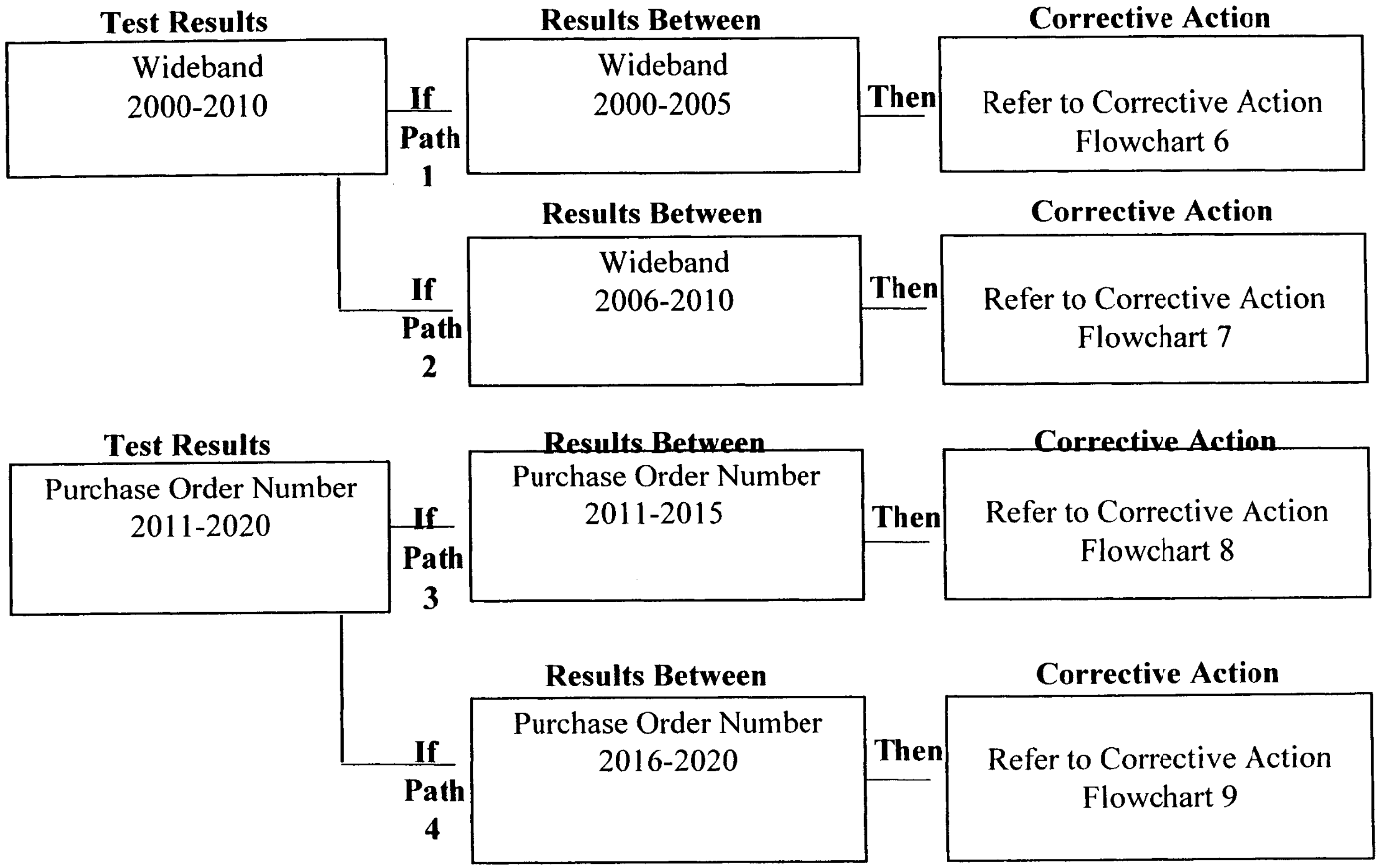
Flowchart 1
Problem: Attenuation

Wideband 2011-2020
Purchase Order Number 2000-2010



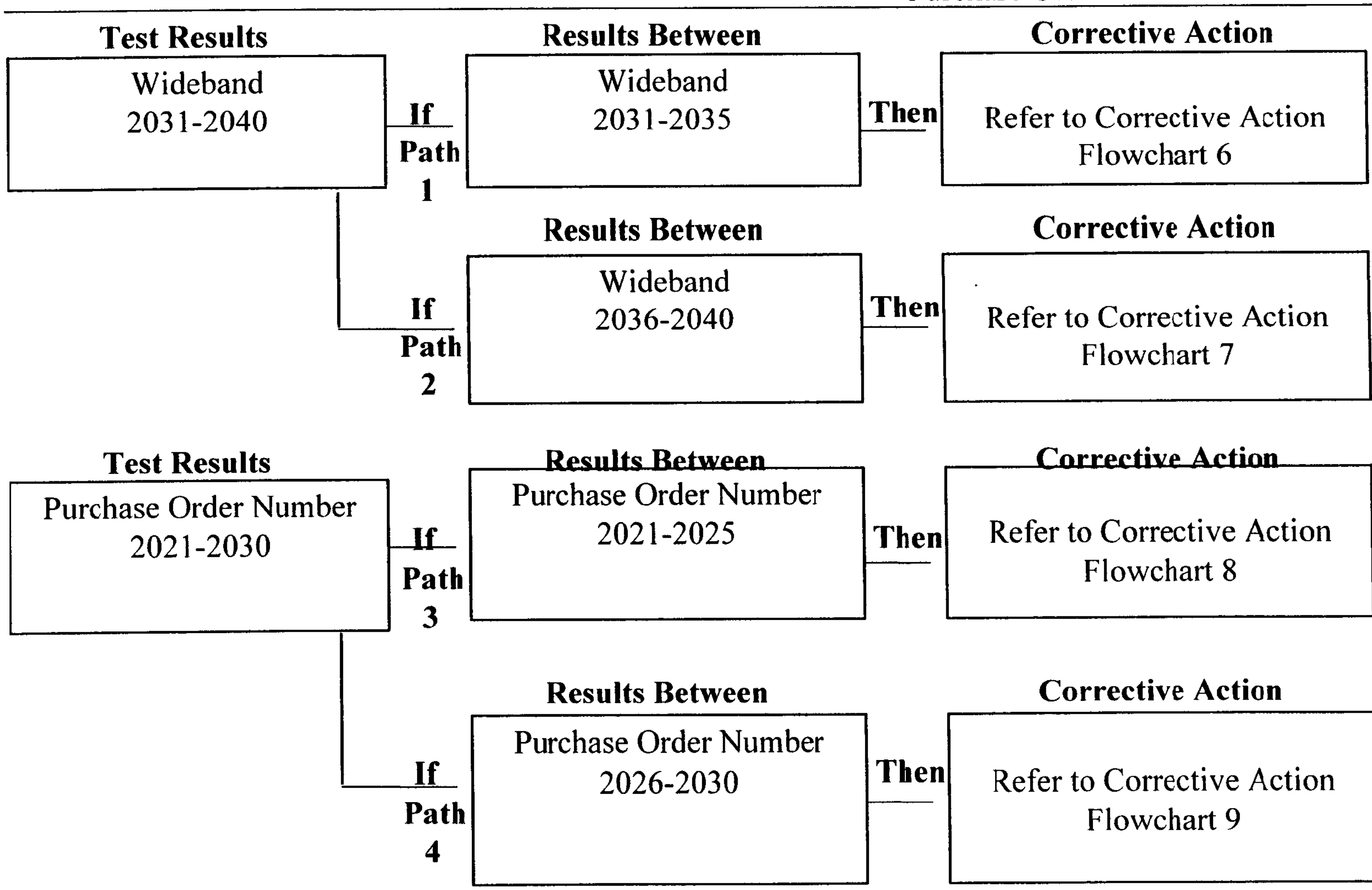
Flowchart 2
Problem: Noise

Wideband 2000-2010
Purchase Order Number 2011-2020



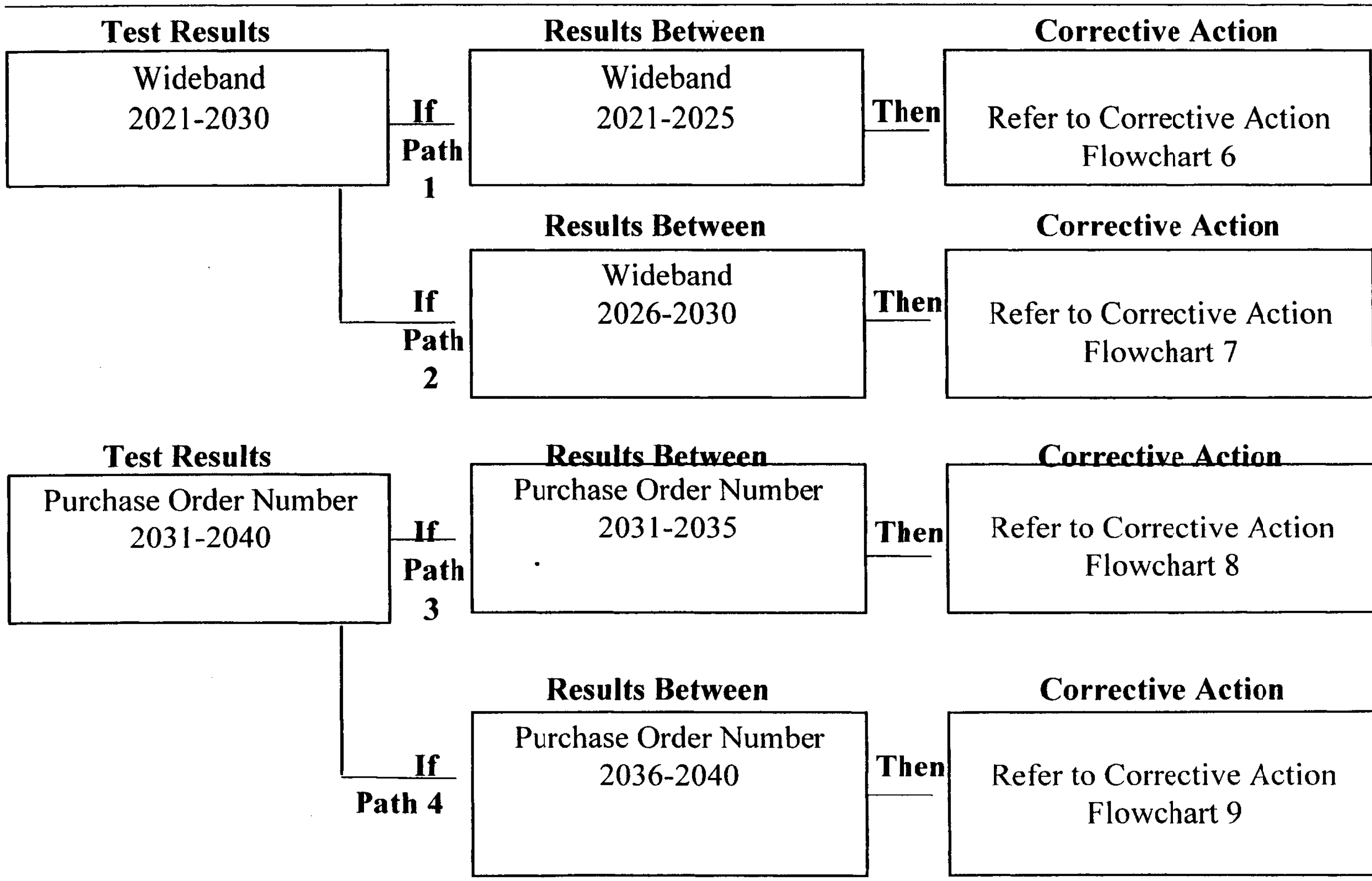
Flowchart 3
Problem: Echoes

Wideband 2031-2040
Purchase Order Number 2021-2030



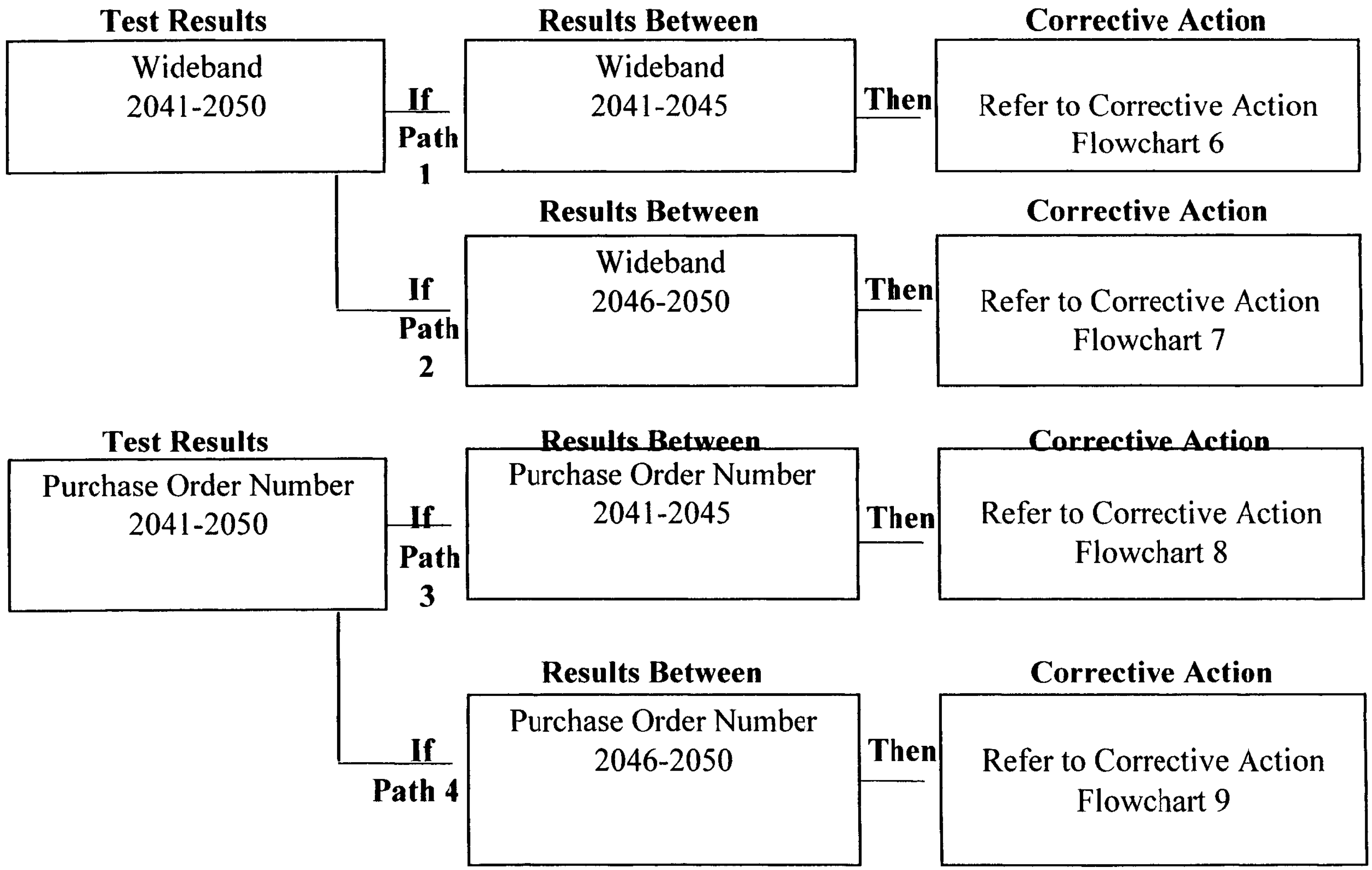
Flowchart 4
Problem: Cross Talk

Wideband 2021-2030
Purchase Order Number 2031-2040

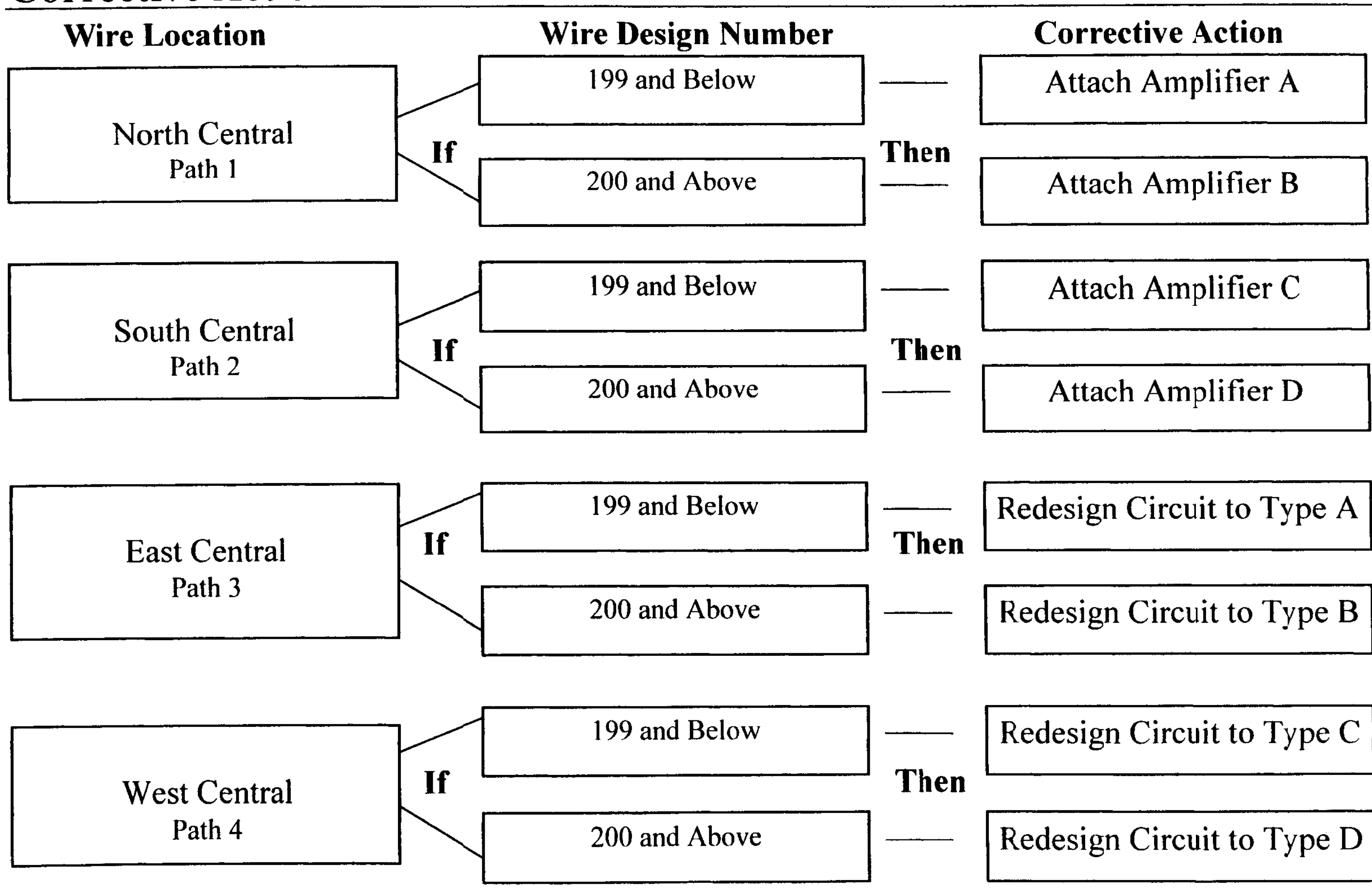


Flowchart 5
Problem: Distortion

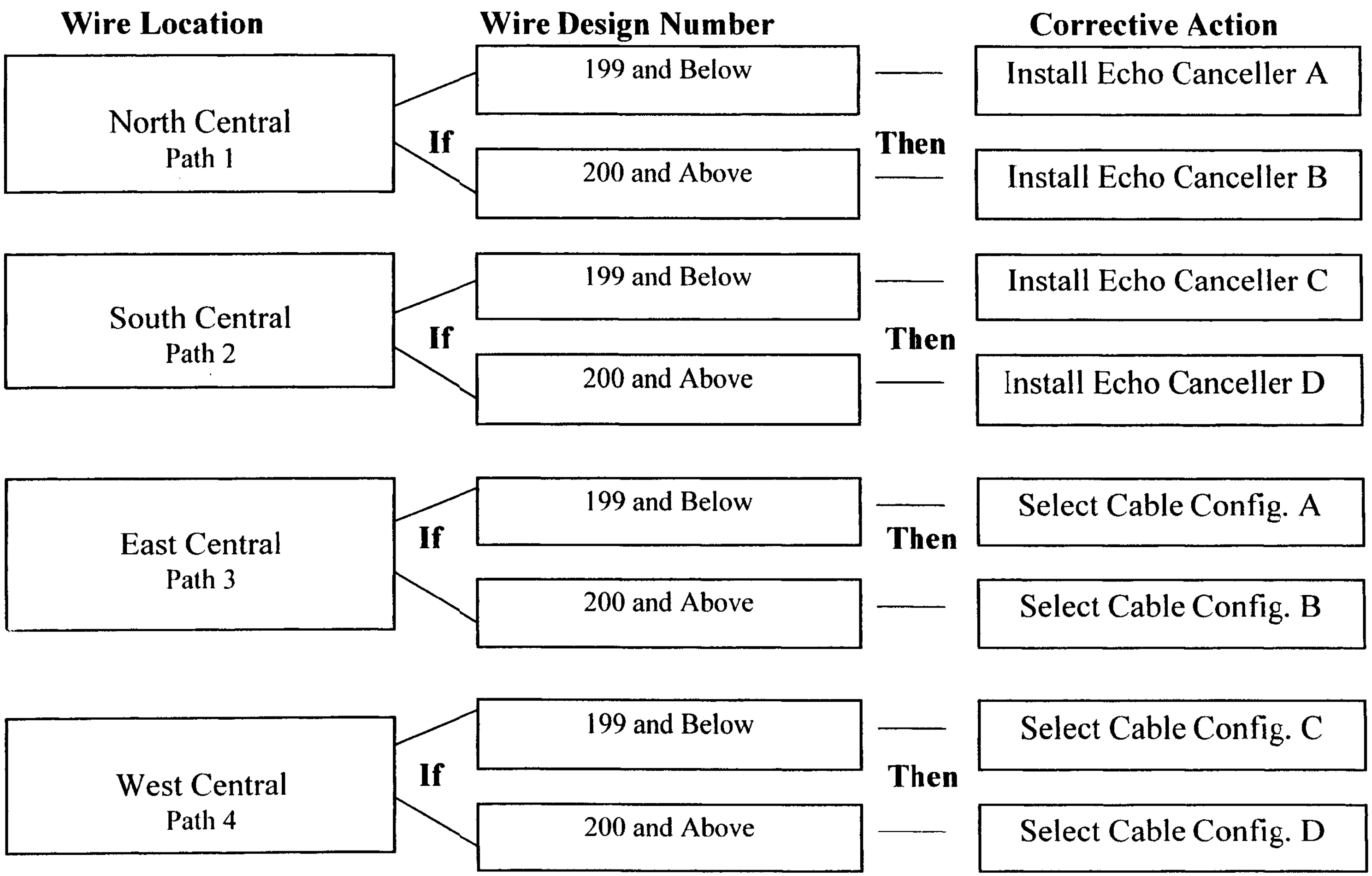
Wideband 2041-2050
Purchase Order Number 2041-2050



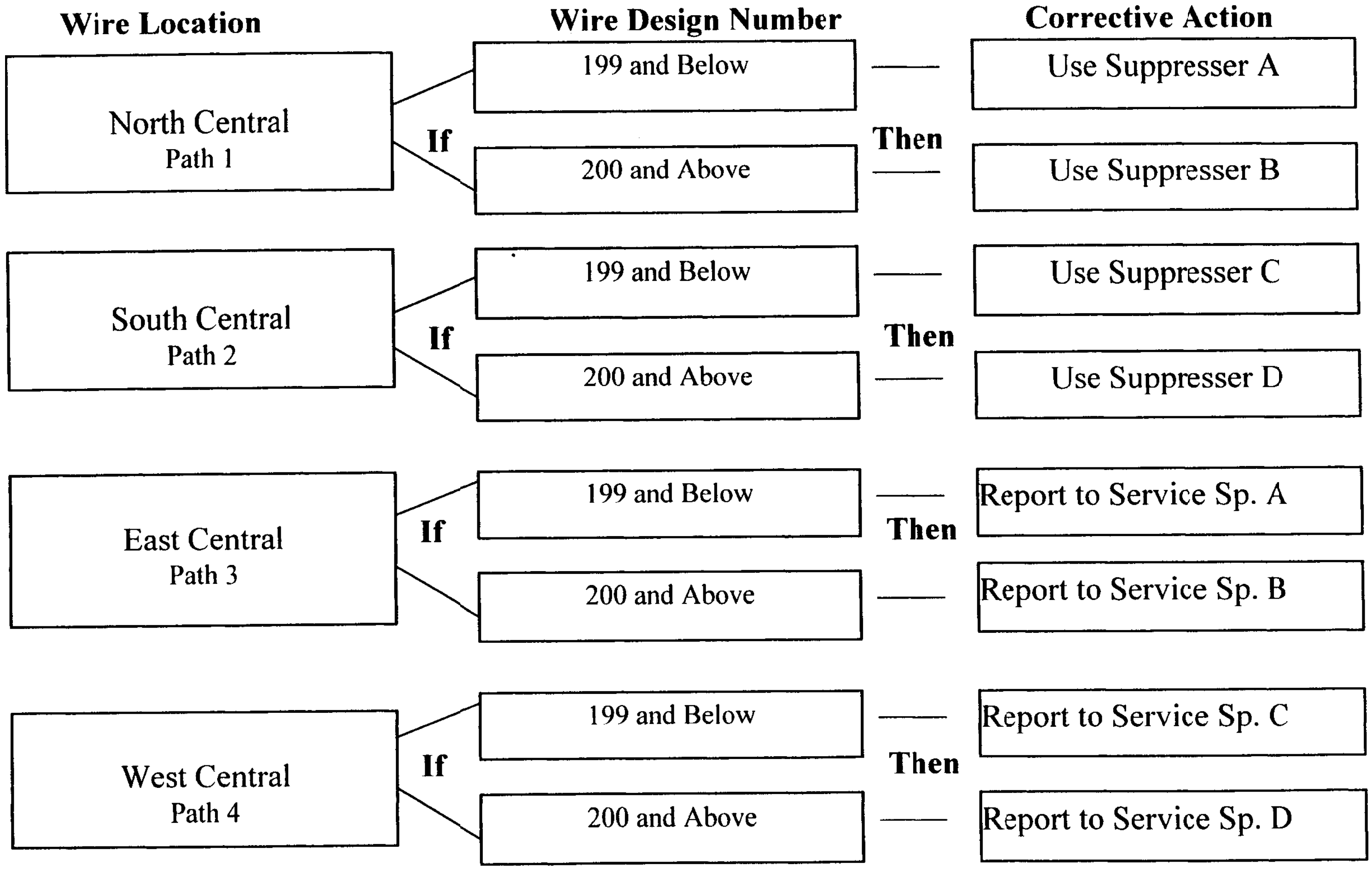
Flowchart 6
Corrective Action



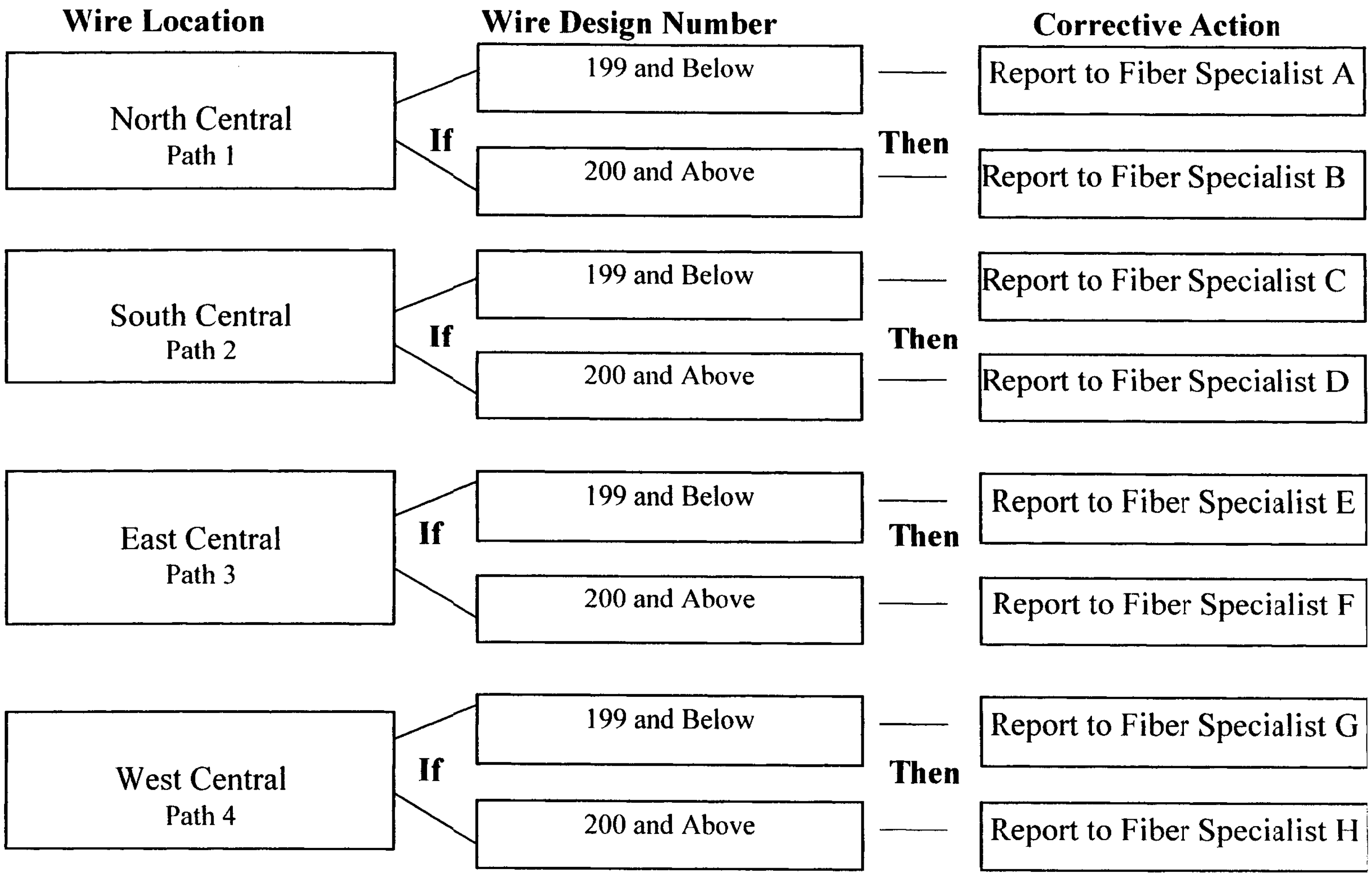
Flowchart 7
Corrective Action



Flowchart 8
Corrective Action



Flowchart 9
Corrective Action



Technician Minicourse

PRETEST TRAINING

MODULE 2

Steps for Troubleshooting Analog and Digital Circuits

Steps for Troubleshooting Circuits

Step 1. Locate the Loop Facility Assignment and Control number and the Wire Specification number.
Refer to the listings in Appendix A to identify the code for Loop Facility Assignment Control System number and the Wire Specification number. Locate the Loop Facilities Assignment Control System number and the Wire Specification number.

Step 2. Compare the two numbers.
If the LFACS number is higher than the Wire Specification number, find the Wideband number (See Appendix for Code) to get the diagnostic test results. If the Wire Specification number is higher than the LFACS number, find the Purchase order number (See Appendix for Code) to get the diagnostic test results.

Step 3. Identify the appropriate troubleshooting flowchart.
Refer to Section B in the Appendix. After identifying the appropriate test results (Wideband or Purchase Order number), locate that number from the WORK Request. Compare that number with the values in the top right hand page to identify the correct troubleshooting flowchart.

Step 4. Determine which path on the flowchart to follow.
Identify which range of values the test results fall between within this initial flowchart.

Step 5. Identify the appropriate corrective action flowchart.
Follow the arrows of the appropriate flowchart path right to identify the appropriate corrective action flowchart.

Step 6. Find the Wire Location.
Refer to the WORK Request to determine the Wire Location.

Step 7. Determine which path on the corrective action flowchart to follow.
With the Wire Location, look at the corrective action flowchart from Section B in the Appendix to identify the correct path to follow.

Step 8. Obtain the Wire Design number.
Refer to the WORK Request to determine the Wire Design number.

Step 9. Determine which sub-path to follow.
If the Wire Design number is **199 and below**, follow the upper route of the path.
If the Wire Design number is **200 and above**, follow the lower route of the path.

Step 10. Identify the appropriate Corrective Action to take.
Follow the route to identify the Corrective Action — the right most column.

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MODULE 2:
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TIMED PRACTICE TEST

The test that follows has 32 questions. You will have 30 minutes to complete.

1. The installation and maintenance of circuits begins with:
   a) Wire Order Reference Document
   b) Work Order Referral Document
   c) Work Operations Reference Document
   d) None of the Above

2. The WORK document is composed of:
   a) two distinct sections
   b) three distinct sections
   c) four distinct sections
   d) none of the above

3. In which section of the WORK document would you find customer information?
   a) first section
   b) second section
   c) third section
   d) all of the above

4. Competition for Bell Atlantic comes from competitive access providers such as AT&T and Sprint. Which code in the WORK document would be most likely to provide information related to competitive access providers?
   a) CAP
   b) BTN
   c) TC
   d) none of the above

5. Which of the following codes in the WORK document provides information about the Billing and Order System Support?
   a) PTN
   b) LSP
   c) NPO
   d) None of the above

6. In which section is information about the wire termination location most likely to be found?
   a) Section 1
   b) Section 2
   c) Section 3
   d) All three sections

WORK Request 1.1

	C.I.	
CN Geary	**CL** north cen	**APC** 322-5567
ATM - No	**BOSS** - 13	**CAP** - Nt
BTN 243-981-6722		
PTN 443-7444		**TC**- 544-2323
	C.S.	
WLO south cen	**LCL** - 333	**WDN** 332
ORd-5/11/xx	**WTL** west cen	**SST** 517
WSN - 131	**LSP** - CO - 4	**ACS** - 944
	W.A.	
RN- 2022	**ONA** - YES	**NPO** 1888
CCSA- Yes	**GTI** 342	**WB** 2117
WRD 55	**POP** - 11	**LFACS** 432

Refer to the above WORK document to answer questions 7 - 10.

7. Which of the following is the Billing and Order System Support code?
   a) 776-7767
   b) 13
   c) 4
   d) 332

8. The Point of Presence code is:
   a) 11
   b) 13
   c) 4 days
   d) 342

9. Which code has a value of 333?
   a) Customer Location
   b) Customer Options
   c) Services Switching Point
   d) Loop Customer Line

10. Which of the following has the highest numerical value?
    a) Wire Request Number
    b) Special Services Test Number
    c) Purchase Order Number
    d) Network Schedule Number

WORK Request 1.2

C.I.

CN Karl	**CL** mid-atlantic	**APC** 332-9320
DACS - 10	**BOC** - Yes	**CALL C** - No
	BTN 450-339-8722	
PTN 450-493-3269		**TC-** 450-239-5920

C.S.

WLO North Atlantic	**LCL-** 312	**WDN** 132
ORd 6/21/xx	**WTL** west cen	**SST** 622
WSN- 330	**LSP-** 16	**ACS** - No

W.A.

RN- 2327	**TCP/IP** - In Use	**NPO** 1230
ONA - 45	**GTI** 128	**ISDN** - No
WRD 61	**WATS** - East	**LFACS** 1344

Refer to the above WORK document to answer the questions 11 - 14

11. Which of the following is not true of WORK document 1.2?
    a) The geographic test index is 128
    b) The circuit switching access is "YES"
    c) The Wide Area Telecommunications Service is East
    d) The open network architecture code is 45

12. Which of the following codes has the value of 1344 in WORK document 1.2?
    a) Purchase Order Number
    b) Service Order Administrative Control number
    c) Digital Access and Cross-Connect code
    d) Loop Facility Assignment and Control System number

13. What is the Billing Telephone Number?
    a) 450-339-8722
    b) 450-493-3269
    c) 450-239-5920
    d) None of the above

14. What is the customer location?
    a) west central
    b) north central
    c) mid-Atlantic
    d) None of the above

For each of the following questions refer carefully to the WORK document presented and then use the troubleshooting steps to answer the questions listed.

WORK Document 2.1

	C.I.	
CN Adams	**CL** Atlantic	**APC** 377-5358
BOSS - Atlas	**DCS** - No	**CTE** - Mid Atlantic
BTN 425-3474		
PTN 396-4474		**TC**- 955-4212
	C.S.	
WLO south cen	**FDDI** - In Use	**WDN** 86
ORd--9/29/xx	**WTL** north central	**SST** 108
WSN-212	**TSN**- 331h	**ACS** - 208
	W.A.	
RN- 1014	**POP** - NO	**NPO** 2044
LSP- east central	**GTI** 245	**WB** - 2024
WRD 925	**WATS** -North	**LFACS** 1027

Refer to the above WORK document to answer the questions 15 - 17

15. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

16. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

17. Which is the corrective action you should take to fix this problem?
    a) Attach Supressor A
    b) Report to Service Specialist C
    c) Use Suppresser C
    d) Attach Amplifier C

WORK Document 2.2

C.I.

CN Watson	**CL** west cen	**APC** 574-8533
WATS - Yes		**ATM** - Yes
BTN 235-122-2221		
PTN 751-6511		**TC** 622-6211

C.S.

WLO east cen	**LCL**-203	**WDN** 121
ORd--11/24/ xx	**WTL** east cen	**SST** 1128
WSN-121	**LSP** - 101	**ACS** - 118

W.A.

RN- 1016	**TCP/IP** - Not In Use	**NPO** 2027
POP - One	**GTI** 160	**WB** - 1001
WRD 1119	**SSC** - Central	**LFACS** 112

Refer to the above WORK document to answer the questions 18 - 20

18. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

19. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

20. Which is the corrective action you should take to fix this problem?
    a) Attach Amplifier A
    b) Report to Fiber Specialist E
    c) Install Echo Canceller A
    d) Attach Amplifier D

WORK Document 2.3

	C.I.	
CN Bauer	**CL** Atlantic	**APC** 737-3358
Boss - Atlas	**DCS** - No	**CTE** - East Atlantic
BTN 554-1474	**PTN** 956-4574	**TC**- 985-3212
	C.S.	
WLO north cent	**FDDI** - In Use	**WDN** 225
ORd--10/29/xx	**WTL** south cen	**SST** 118
WSN-181	**TSN**- 212	**ACS**- 345
	W.A.	
RN- 1014	**TCP/IP** - In Use	**NPO** 8866
LSP- east cen	**GTI** 285	**WB** - 2049
WRD 1025	**WATS** - NO	**LFACS** 1027

Refer to the above WORK document to answer the questions 21 - 23

21. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

22. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

23. Which is the corrective action you should take to fix this problem?
    a) Report to Service Specialist A
    b) Attach Amplifier A
    c) Install Echo Canceller B
    d) Report to Service Specialist B

WORK Document 2.4

C.I.

CN Simmons	**CL** Mid-Atlantic	**APC** 567-3458
Boss - Atlas	**DCS** - No	**CTE** - South Atlantic
BTN 534-1474		
PTN 356-4574		**TC**- 955-3212

C.S.

WLO east cen	**FDDI** - In Use	**WDN** 225
ORd--10/29/xx	**WTL** south central	**SST** 118
WSN-2226	**TSN**- 544	**ACS**- 225

W.A.

RN- 1014	**POP** - NO	**NPO** 2014
LSP- east cen	**GTI** 182	**WB** - 2024
WRD 1025	**CWS**- 1200	**LFACS** 1027

Refer to the above WORK document to answer the questions 24 - 26

24. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

25. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

26. Which is the corrective action you should take to fix this problem?
    a) Report to Service Specialist B
    b) Attach Supressor D
    c) Report to Fiber Specialist C
    d) Report to Fiber Specialist D

WORK Document 2.5

	C.I.	
CN Davis **WATS** - Yes **BTN** 235-112-1121 **PTN**751-6511	**CL** east cen	**APC** 544-2533 **ATM** - Yes **TC** 232-2311
	C.S.	
WLO east cen **ORd**--11/24/ xx **WSN**-110	**LCL-WEST** **WTL** west cen **TSN** - 101	**WDN** 121 **SST** 1128 **ACS** - 111
	W.A.	
RN- 1016 **POP**- One **WRD** 1119	**TCP/IP** - Not In Use **GTI** 282 **SSC** - Central	**NPO** 2050 **WB** - 2022 **LFACS** 122

Refer to the above WORK document to answer the questions 27 - 29

27. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

28. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

29. Which is the corrective action you should take to fix this problem?
    a) Attach Amplifier C
    b) Attach Amplifier D
    c) Redesign Circuit to Type A
    d) Redesign Circuit to Type B

WORK Document 2.6

	C.I.	
CN McCann **WATS** - Yes **BTN** 775-312-4453	**CL** west cen	**APC** 434-3325 **ATM** - Yes
PTN 881-7911		**TC** 988-2311
	C.S.	
WLO south cen	**LCL-WEST**	**WDN** 121
ORd--11/24/ xx	WTL west cen	**SST** 1128
WSN-321	**LSP** - 101	**ACS** - 244
	W.A.	
RN- 1016	**TCP/IP** - Not In Use	**NPO** 2002
POP- One	**GTI** 122	**WB** - 2012
WRD 1119	**CWS** - NO	**LFACS** 122

Refer to the above WORK document to answer the questions 30 - 32

30. Which is the correct initial flowchart you should use to determine this problem?
    a) Flow Chart 1
    b) Flow Chart 2
    c) Flow Chart 3
    d) Flow Chart 4
    e) Flow Chart 5

31. Which is the correct Path on the initial flowchart you should follow in this problem?
    a) Path 1
    b) Path 2
    c) Path 3
    d) Path 4

32. Which is the corrective action you should take to fix this problem?
    a) Use Supressor C
    b) Use Supressor D
    c) Redesign Circuit to Type A
    d) Redesign Circuit to Type B

Technician Minicourse
PRETEST TRAINING

MODULE 2:
Understanding Technical Documents and Troubleshooting Circuits

Answers to Timed Practice Test

1. The installation and maintenance of circuits begins with:
   Correct answer = **b) Work Order Referral Document**
   (p3) The installation and maintenance of circuits begins with the receipt of an official authorization document. Over the years, a variety of documents were used for this purpose. Even though they had different names and looked different, these documents all served the same purpose. One such document is the **WORK (Work Order Referral Document) Request**

2. The WORK Request is composed of:
   Correct Answer = **b) three distinct sections**
   (p. 4) The WORK Request is composed of **3 distinct sections**, each with a specific purpose:

3. In which section of the WORK Request would you find customer information?
   Correct Answer = a) first section
   (p. 3) The first portion of the WORK Request is the **customer information section**

4. Competition for Bell Atlantic comes from competitive access providers such as AT&T and Sprint. Which code in the WORK document would be most likely to provide information related to competitive access providers?
   Correct Answer – a) CAP
   Answer can be obtained by looking through the appendix.

5. Which of the following codes in the WORK document provides information about the Billing and Order System Support?
   Correct Answer = d) None of the above
   Code is BOSS, which can be found in the Appendix.

6. In which section is information about the wire termination location most likely to be found?
   Correct Answer = b) Section 2
   Answer can be found in solution to problem 1.2

WORK Request 1.1

	C.I.	
CN Geary	**CL** north cen	**APC** 322-5567
ATM - No	**BOSS** - 13	**CAP** - Nt
BTN 243-981-6722		
PTN 443-7444		**TC**- 544-2323
	C.S.	
WLO south cen	**LCL** - 333	**WDN** 332
ORd-5/11/xx	**WTL** west cen	**SST** 517
WSN - 131	**LSP** - CO - 4	**ACS** - 944
	W.A.	
RN- 2022	**ONA** - YES	**NPO** 1888
CCSA- Yes	**GTI** 342	**WB** 2117
WRD 55	**POP** - 11	**LFACS** 432

Refer to the above WORK document to answer questions 7 - 10.

7. Which of the following is the Billing and Order System Support code?
   Correct answer = b) 13

The code is BOSS which can be found in first section of the WORK Request.

8. The Point of Presence code is:
   Correct answer = a) 11
   Code is POP which can be found in third section of WORK Request

9. Which code has a value of 333?
   Correct answer = d) Loop Customer Line

Correct code is LCL which can be found in second section of WORK Request

10. Which of the following has the highest numerical value?

Correct answer = c) Purchase Order Number

a) Wire Request Number (WRD)	55
b) Special Services Test Number (SST)	517
c) *Purchase Order Number (NPO)	1888
d) Network Schedule Date	Does not exist

Note: C is the correct answer

WORK Request 1.2

	C.I.	
CN Karl	**CL** mid-atlantic	**APC** 332-9320
DACS - 10	**BOC** - Yes	**CALL C** - No
	BTN 450-339-8722	
PTN 450-493-3269		**TC-** 450-239-5920
	C.S.	
WLO North Atlantic	**LCL-** 312	**WDN** 132
ORd 6/21/xx	**WTL** west cen	**SST** 622
WSN- 330	**LSP-** 16	**ACS** - No
	W.A.	
RN- 2327	**TCP/IP** - In Use	**NPO** 1230
ONA - 45	**GTI** 128	**ISDN** - No
WRD 61	**WATS** - East	**LFACS** 1344

Refer to the above WORK Request to answer the questions 11 - 14

11. Which of the following is **not** true of WORK request 1.2?
    Correct Answer = b)The circuit switching access is "YES"
    ACS is code for circuit switching access (see Appendix) and = no in WORK Request 1.2.

12. Which of the following codes has the value of 1344 in WORK document 1.2?
    Correct answer = **d) Loop Facility Assignment and Control System number**
    Code is LFACS (See Appendix)

13. What is the Billing Telephone Number?
    Correct answer = a) 450-339-8722
    Code is BTN (see Appendix)

14. What is the customer location?
    Correct answer = c) mid-Atlantic
    Code is CL (See Appendix)

WORK Document 2.1

C.I.

CN Adams	**CL** Atlantic	**APC** 377-5358
BOSS - Atlas	**DCS** - No	**CTE** - Mid Atlantic
BTN 425-3474		
PTN 396-4474		**TC**- 955-4212

C.S.

WLO south cen	**FDDI** - In Use	**WDN** 86
ORd--9/29/xx	**WTL** north central	**SST** 108
WSN-212	**TSN**- 331h	**ACS** - 208

W.A.

RN- 1014	**POP** - NO	**NPO** 2044
LSP- east central	**GTI** 245	**WB** - 2024
WRD 925	**WATS** -North	**LFACS** 1027

Refer to the above WORK document to answer the questions 15 - 17

15. Which is the correct initial flowchart you should use to determine this problem?
    Correct answer = d) Flow Chart 4

16. Which is the correct Path on the flowchart you should follow in this problem?
    Correct Answer = a) *Path 1

17. Which is the corrective action you should take to fix this problem?
    d) *Attach Amplifier C

Step	Outcome
1. Locate LFACs and WSN numbers	LFACS=1027, WSN =212
2. Compare two numbers	LFACS is higher, use WB = 2024
3. Identify appropriate troubleshooting flowchart	2024 falls between 2021-2030 so Flowchart 4 should be used
4. Determine which path to follow	Since 2024 is between 2021-2025, Path 1 is the correct path
5. Identify appropriate corrective action flowchart	Corrective action flowchart 6 is correct
6. Find Wire Location (WLO)	South central
7. Determine which path on corrective action flowchart to follow	South Central is Path 2
8. Find Wire Design Number	Find Wire Design Number (WDN) = 86
9. Determine which sub-path to follow	86 is below 200 so follow upper route of Path 2
10. Identify appropriate corrective action	Attach Amplifier C

WORK Document 2.2

	C.I.	
CN Watson	**CL** west cen	**APC** 574-8533
WATS - Yes		**ATM** - Yes
BTN 235-122-2221		
PTN 751-6511		**TC** 622-6211
	C.S.	
WLO east cen	**LCL**-203	**WDN** 121
ORd--11/24/ xx	**WTL** east cen	**SST** 1128
WSN-121	**LSP** - 101	**ACS** - 118
	W.A.	
RN- 1016	**TCP/IP** - Not In Use	**NPO** 2027
POP - One	**GTI** 160	**WB** - 1001
WRD 1119	**SSC** - Central	**LFACS** 112

Refer to the above WORK document to answer the questions 18 - 20

18. Which is the correct initial flowchart you should use to determine this problem?
Correct answer = c) Flowchart 3

19. Which is the correct Path on the flowchart you should follow in this problem?
Correct answer = d) Path 4

20. Which is the corrective action you should take to fix this problem?
Correct answer = b) Report to Fiber Specialist E

Step	Outcome
1. Locate LFACs and WSN numbers	LFACS=112, WSN =121
2. Compare two numbers	WSN is higher, use NPO = 2027
3. Identify appropriate troubleshooting flowchart	2027 falls between 2021-2030 so Flowchart 3 should be used
4. Determine which path to follow	Since 2027 is between 2026-2030, Path 4 is the correct path
5. Identify appropriate corrective action flowchart	Corrective action flowchart 9 is correct
6. Find Wire Location (WLO)	East central
7. Determine which path on corrective action flowchart to follow	East Central is Path 4
8. Find Wire Design Number	Find Wire Design Number (WDN) = 121
9. Determine which sub-path to follow	121 is below 200 so follow upper route of Path 3
10. Identify appropriate corrective action	Report to Fiber Specialist E

WORK Document 2.3

	C.I.	
CN Bauer	**CL** Atlantic	**APC** 737-3358
Boss - Atlas	**DCS** - No	**CTE** - East Atlantic
BTN 554-1474	**PTN** 956-4574	**TC**- 985-3212
	C.S.	
WLO north cent	**FDDI** - In Use	**WDN** 225
ORd--10/29/xx	**WTL** south cen	**SST** 118
WSN-181	**TSN**- 212	**ACS**- 345
	W.A.	
RN- 1014	**TCP/IP** - In Use	**NPO** 8866
LSP- east cen	**GTI** 285	**WB** - 2049
WRD 1025	**WATS** - NO	**LFACS** 1027

Refer to the above WORK document to answer the questions 21 - 23

21. Which is the correct initial flowchart you should use to determine this problem?
    Correct answer = e) Flow Chart 5

22. Which is the correct Path on the flowchart you should follow in this problem?
    b) *Path 2

23. Which is the corrective action you should take to fix this problem?
    Correct Answer = c) * Install Echo Canceller B

Step	Outcome
1. Locate LFACs and WSN numbers	LFACS=1027, WSN =181
2. Compare two numbers	LFACS is higher, use WB = 2049
3. Identify appropriate troubleshooting flowchart	2049 falls between 2041-2050 so Flowchart 5 should be used
4. Determine which path to follow	Since 2049 is between 2046-2050, Path 2 is the correct path
5. Identify appropriate corrective action flowchart	Corrective action flowchart 7 is correct
6. Find Wire Location (WLO)	North central
7. Determine which path on corrective action flowchart to follow	North Central is Path 1
8. Find Wire Design Number	Find Wire Design Number (WDN) = 225
9. Determine which sub-path to follow	121 is below 200 so follow upper route of Path 1
10. Identify appropriate corrective action	Install Echo Canceller B

WORK Document 2.4

	C.I.	
CN Simmons **Boss** - Atlas **BTN** 534-1474 **PTN** 356-4574	**CL** Mid-Atlantic **DCS** - No	**APC** 567-3458 **CTE** - South Atlantic **TC**- 955-3212
	C.S.	
WLO east cen **ORd**--10/29/xx **WSN**-2226	**FDDI** - In Use **WTL** south central **TSN**- 544	**WDN** 225 **SST** 118 **ACS**- 225
	W.A.	
RN- 1014 **LSP**- east cen **WRD** 1025	**POP** - NO **GTI** 182 **CWS**- 1200	**NPO** 2014 **WB** - 2024 **LFACS** 1027

Refer to the above WORK document to answer the questions 24 - 26

24. Which is the correct initial flowchart you should use to determine this problem?
    Correct answer = b) Flow Chart 2

25. Which is the correct Path on the **initial** flowchart you should follow in this problem?
    Correct answer = c) Path 3

26. Which is the corrective action you should take to fix this problem?
    Correct answer = a) Report to Service Specialist B

Step	Outcome
1. Locate LFACs and WSN numbers	LFACS=1027, WSN =2226
2. Compare two numbers	WSN is higher, use NPO= 2014
3. Identify appropriate troubleshooting flowchart	2014 falls between 2011-2020 so Flowchart 2 should be used
4. Determine which path to follow	Since 2014 is between 2011-2014, Path 3 is the correct path
5. Identify appropriate corrective action flowchart	Corrective action flowchart 8 is correct
6. Find Wire Location (WLO)	East central
7. Determine which path on corrective action flowchart to follow	East Central is Path 3
8. Find Wire Design Number	Find Wire Design Number (WDN) = 225
9. Determine which sub-path to follow	225 is above 200 so follow lower route of Path 3
10. Identify appropriate corrective action	Report to Service Specialist B

WORK Document 2.5

	C.I.	
CN Davis	CL east cen	**APC** 544-2533
WATS - Yes		**ATM** - Yes
BTN 235-112-1121		
PTN751-6511		**TC** 232-2311
	C.S.	
WLO east cen	**LCL-WEST**	**WDN** 121
ORd--11/24/ xx	**WTL** west cen	**SST** 1128
WSN-110	**TSN** - 101	**ACS** - 111
	W.A.	
RN- 1016	**TCP/IP** - Not In Use	**NPO** 2050
POP- One	**GTI** 282	**WB** - 2022
WRD 1119	**SSC** - Central	**LFACS** 122

Refer to the above WORK document to answer the questions 27 - 29

27. Which is the correct initial flowchart you should use to determine this problem?
    Correct answer = d) Flow Chart 4

28. Which is the correct Path on the flowchart you should follow in this problem?
    Correct answer = a) Path 1

29. Which is the corrective action you should take to fix this problem?
    Correct answer = c) Redesign Circuit to Type A

Step	Outcome
1. Locate LFACs and WSN numbers	LFACS=122, WSN =110
2. Compare two numbers	LFACS is higher, use WB= 2022
3. Identify appropriate troubleshooting flowchart	2022 falls between 2021-2030 so Flowchart 4 should be used
4. Determine which path to follow	Since 2022 is between 2021-2025, Path 1 is the correct path
5. Identify appropriate corrective action flowchart	Corrective action flowchart 6 is correct
6. Find Wire Location (WLO)	East central
7. Determine which path on corrective action flowchart to follow	East Central is Path 3
8. Find Wire Design Number	Find Wire Design Number (WDN) = 121
9. Determine which sub-path to follow	121 is below 200 so follow upper route of Path 3
10. Identify appropriate corrective action	Redesign to Circuit Type A

WORK Document 2.6

	C.I.	
CN McCann	**CL** west cen	**APC** 434-3325
WATS - Yes		**ATM** - Yes
BTN 775-312-4453		
PTN 881-7911		**TC** 988-2311
	C.S.	
WLO south cen	**LCL-WEST**	**WDN** 121
ORd--11/24/ xx	WTL west cen	**SST** 1128
WSN-321	**LSP** - 101	**ACS** - 244
	W.A.	
RN- 1016	**TCP/IP** - Not In Use	**NPO** 2002
POP- One	**GTI** 122	**WB** - 2012
WRD 1119	**CWS** - NO	**LFACS** 122

Refer to the above WORK document to answer the questions 30 - 32

30. Which is the correct initial flowchart you should use to determine this problem?
    Correct answer = Flow Chart 1

31. Which is the correct Path on the flowchart you should follow in this problem?
    Correct answer = c) *Path 3

32. Which is the corrective action you should take to fix this problem?
    Correct answer = a) *Use Supressor C

Step	Outcome
11. Locate LFACs and WSN numbers	LFACS=122, WSN =321
12. Compare two numbers	WSN is higher, use NPO= 2002
13. Identify appropriate troubleshooting flowchart	2002 falls between 2001-2010 so Flowchart 1 should be used
14. Determine which path to follow	Since 2002 is between 2001-2005, Path 3 is the correct path
15. Identify appropriate corrective action flowchart	Corrective action flowchart 8 is correct
16. Find Wire Location (WLO)	South central
17. Determine which path on corrective action flowchart to follow	South Central is Path 2
18. Find Wire Design Number	Find Wire Design Number (WDN) = 121
19. Determine which sub-path to follow	121 is below 200 so follow upper route of Path 2
20. Identify appropriate corrective action	Use Suppresser C

MODULE 2: UNDERSTANDING TECHNICAL DOCUMENTS & TROUBLESHOOTING CIRCUITS
Pretest Training Timed Practice Performance Test
ANSWER SHEET

Record your answers to the test questions by circling your answer choices on this page.
You will have *30 minutes* to complete this portion of the test.

1)	a	b	c	d	
2)	a	b	c	d	
3)	a	b	c	d	
4)	a	b	c	d	
5)	a	b	c	d	
6)	a	b	c	d	
7)	a	b	c	d	
8)	a	b	c	d	
9)	a	b	c	d	
10)	a	b	c	d	
11)	a	b	c	d	
12)	a	b	c	d	
13)	a	b	c	d	
14)	a	b	c	d	
15)	a	b	c	d	e
16)	a	b	c	d	

17)	a	b	c	d	
18)	a	b	c	d	e
19)	a	b	c	d	
20)	a	b	c	d	
21)	a	b	c	d	e
22)	a	b	c	d	
23)	a	b	c	d	
24)	a	b	c	d	e
25)	a	b	c	d	
26)	a	b	c	d	
27)	a	b	c	d	e
28)	a	b	c	d	
29)	a	b	c	d	
30)	a	b	c	d	e
31)	a	b	c	d	
32)	a	b	c	d	