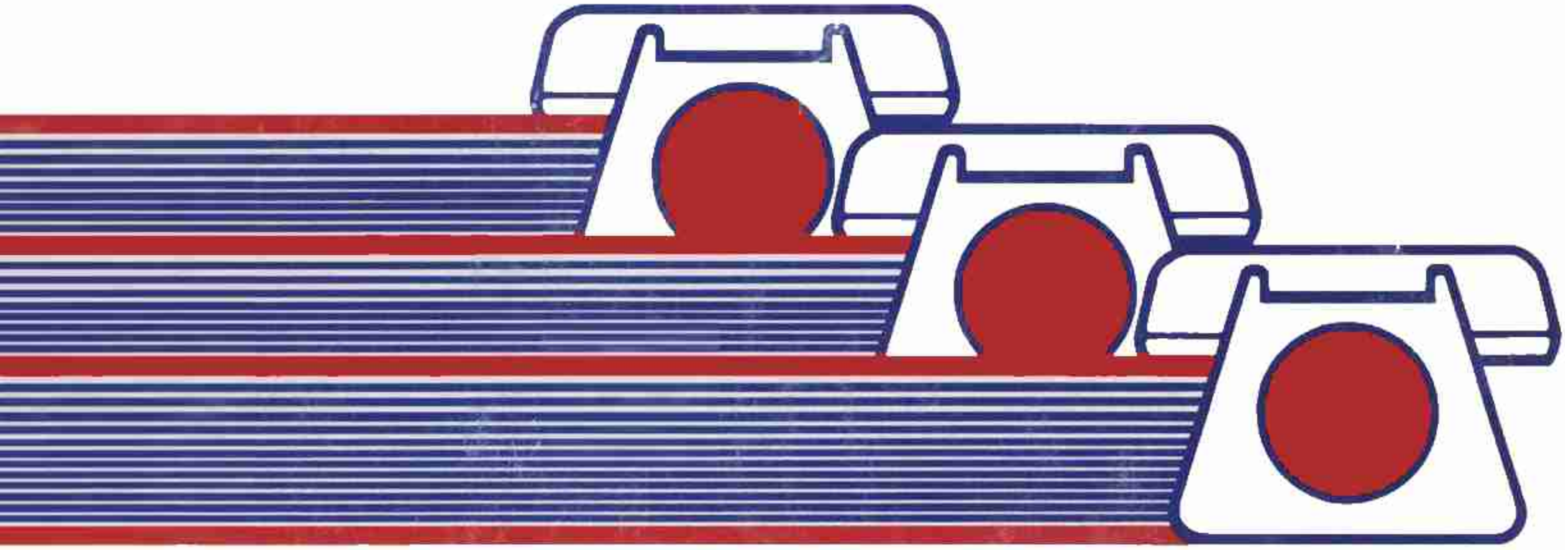
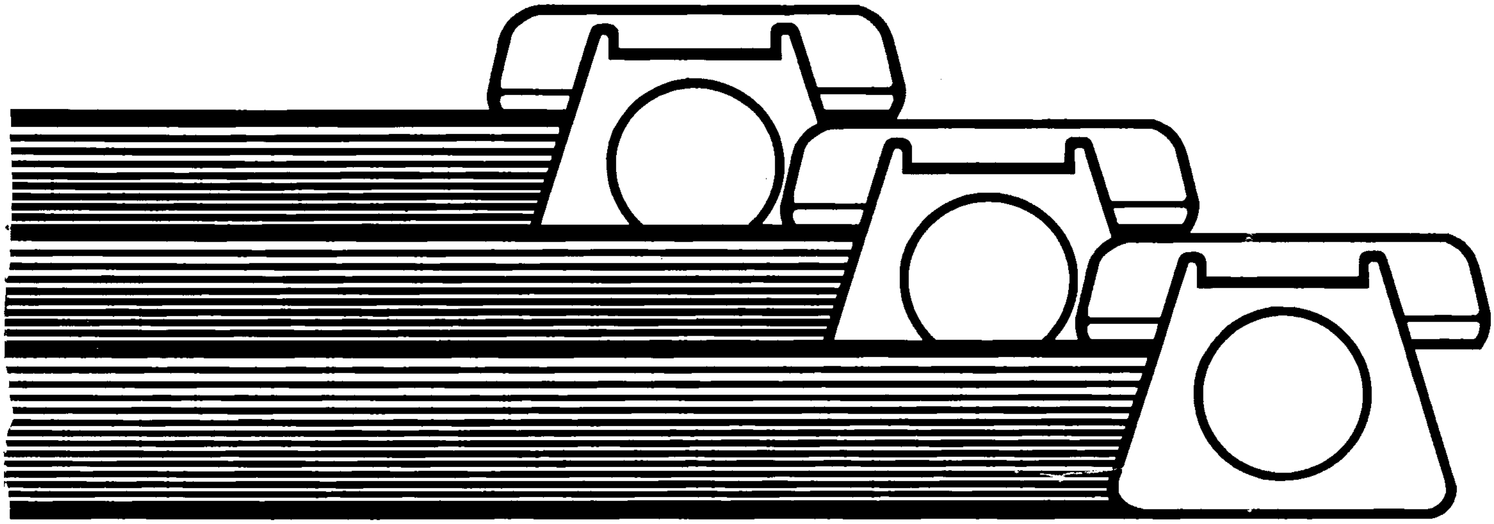
Special Services Telephony



An Introduction to Transmission and Signaling

tellabs

Special Services Telephony



An Introduction to Transmission and Signaling

tellabs

Tellabs

Generic Telephony Training

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Generic Telephony Training

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**Introduction:
Generic Training**

You're about to come in contact with a lot of information about telephones, electronics and the various devices which make communications systems work in many different situations. Sometimes the information may seem very simple, obvious in fact. Other times you may have to re-read a paragraph before you thoroughly understand it. One way or another, this course will make you think.

**Explanation:
Text Rationale**

We've tried hard to keep this training geared very closely to the tasks you'll be performing on the job. We've structured the information so it's easy to get at. We've written the text in these short block paragraphs so that it's easy to read. And we've tried to present each idea within a single page or two so there's not a lot of extra reading to wade through.

**Application:
The Training Package**

This text material is meant to be presented along with some video tapes. There is a generic program which closely parallels the texts and provides an overview for what you'll read here. And there are also Tellabs Technical Training videos and Practices which will show you, in detail, how to install specific Tellabs modules.

**Comment:
Reinforcement
Quizzes**

Because we've designed this training to be used in a lot of different ways — led by an instructor, led by your supervisor, or studied independently — we've included a series of very short, easy exercises and have interspersed them along with the text after each chunk of information.

They're just quick little quizzes to help you make sure that you've understood what we just presented. It also helps you to know what information you'll need to review. And ultimately, it helps us to know if we've explained things properly.

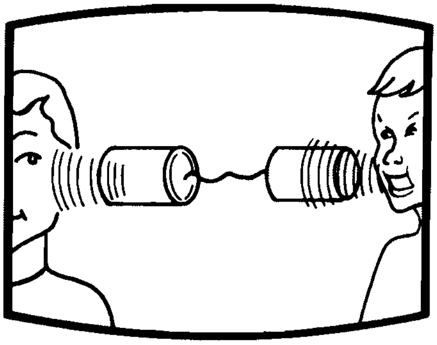
In any case, you won't be graded on these tests, so you don't need to worry about them. If you do have any trouble with any item, it would probably be good to ask your instructor or supervisor for some help in that area. The quizzes start out pretty easy. But they get more complex as you go along. And they'll give you good practice for when you start working with the equipment.

**Note:
Why Generic Training**

What we're trying to do here is to give you some background in Special Services Telephony. You'll find that this craft area can get complex at times, because not all of the circuits you'll be working on will follow the norm. We hope that this training will give you a useful, basic understanding so that you'll be able to handle any installation problems should they arise.

We're also interested in your feelings about the training. If you have anything in particular to say, corrections, criticisms or comments, please give us a call or send a note. We do care. And we want to help.

Illustration: Transmission



Introduction: Transmission

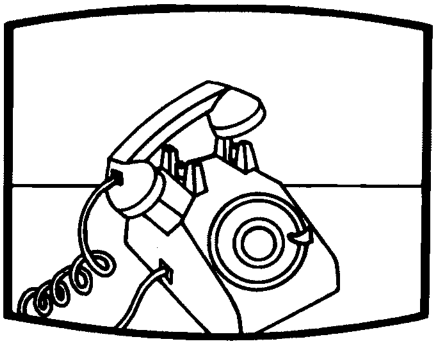
The complexity of the telephone circuit is closely tied to distance. The shorter the distance, the simpler the system. These tin can phones are sufficient for crossing Tim and Jerry's backyard. And they're fun too.

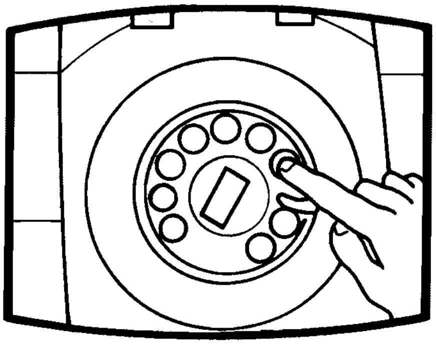
On their simple tin cans, Jerry and Tim stumbled on a basic telephone concept. They can talk — Transmit.

Or hear — Receive. But they can only do it in one direction at a time.

The string is the facility that connects the tin cans and carries their voices. Real telephone circuits accomplish voice transmission in much the same way.

Illustration: Signaling

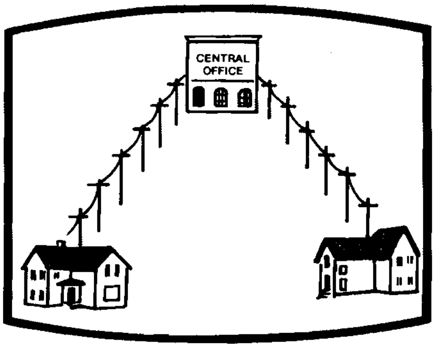




Explanation

But their dedicated tin can circuit has a major drawback. There is no signaling. How do you get the other party to know you're calling? In real phone circuits, we use different types of signaling. Bells and buzzers. Dial pulsing. Dial tones and busy signals. But these signaling functions just don't exist in a couple of tin cans.

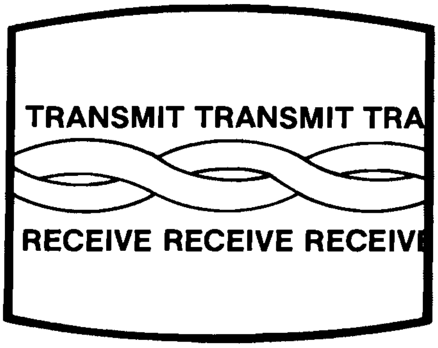
**Illustration/
Explanation:
POTS Circuit**



Now the two boys talk over a real telephone. They're connected to each other through a Central Office by a 2 Wire POTS circuit. That's POTS or Plain Ordinary Telephone Service.

The Central Office or C.O. switches all calls, provides signaling and supervision. And supplies power and ringing to the boys' two telephones.

**Illustration/
Explanation:
Tip and Ring**

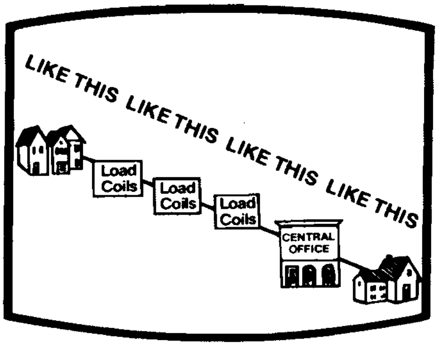


The 2 Wire circuit works well over relatively short distances. But it has complications of its own. Because there are only two wires, Tip and Ring, it means that the Transmit and Receive functions have to share the same path. This is bi-directional transmission. And it's the rule for 2 Wire circuits.

But as the loop gets longer, transmission and signaling quality diminish. We saw this clearly when Jerry moved to a new house a few blocks away.

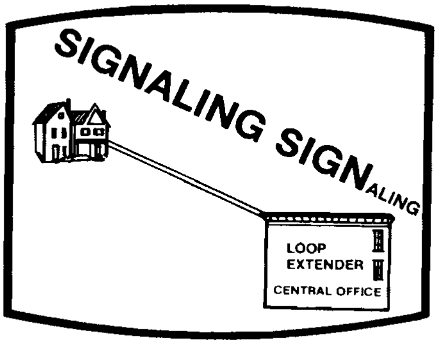
The first thing to deteriorate over distance is voice quality or frequency response. High frequencies are affected more than low frequencies.

**Illustration/
Explanation:
Load Coils**



So, to correct that, we add load coils along the length of the facility. This cable loading allows the voice to pass more efficiently, hence improving frequency response.

**Illustration/
Explanation:
Loop Extender**

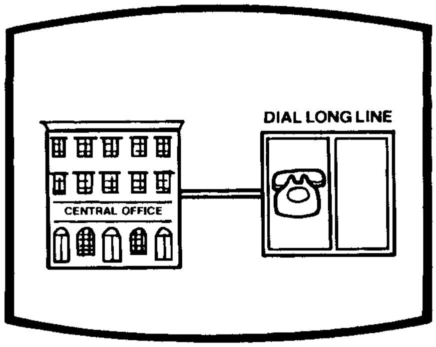


The load coils improve transmission frequency response. But signaling is also affected by distance. To solve this problem we add a Loop Extender to the circuit at the Central Office. This floating power source beefs up the signaling so that it can cover almost twice the distance.

Application: Dial Long Line

Before Jerry's latest move, we'd already stretched signaling on that 2 Wire circuit just about as far as the Loop Extender could take it. So to improve signaling, we added a Dial Long Line between the new house and the Central Office.

Illustration/ Explanation: Dial Long Line



The Dial Long Line looks like a regular telephone to the C.O.:

- repeats dial pulsing,
- regenerates off-hook,
- detects ringing,

And it acts like a Central Office to the phone by providing:

- battery
- loop sense
- ring trip.

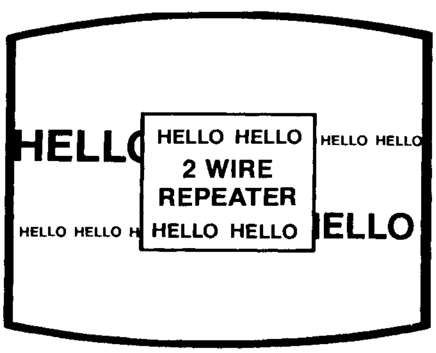
So as long as the signaling information reaches the Dial Long Line, it'll be repeated and sent along its way.

Application: Repeater

O.K. the Dial Long Line helps out the signaling, but what about transmission quality? Load coils improve frequency response *some*. But there's too much loss — attenuation — for them to do much good over this distance. To make up for this loss, an Amplifier or 2 Wire Repeater is used.

It boosts voice levels in both directions, but Amplifiers or 2 Wire Repeaters *do* have some inherent problems.

Illustration/ Explanation: 2 Wire Repeater



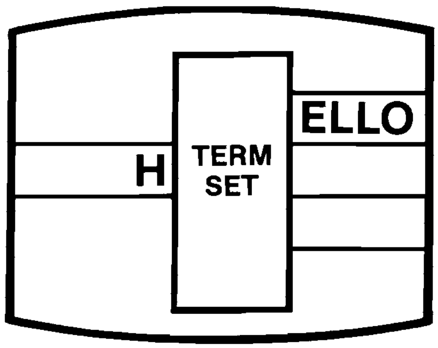
They can sound hollow. Feed back. Or sing like this. And because of these problems, the Repeater can't boost the voice level enough to make it effective over extremely long distances. But it's just enough for this application.

**Application:
4 Wire Transmission**

Even with 2 Wire Repeaters installed, the voice level is still not acceptable in a longer circuit. So to compensate for the extended distance, the boys have to use a combination of 2 Wire and 4 Wire circuits.

The 4 Wire circuits are highly efficient transmission media because they have separate transmit and receive paths. But we use them only when they're absolutely needed in order to keep costs down.

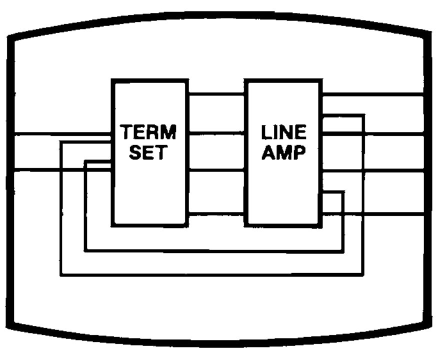
**Illustration/
Explanation:
Term Set**



But in order for the boys to talk to each other — over Tim's 2 Wire circuit and Jerry's 4 Wire circuit — we've got to make a very special type of connection. This is done with a terminating set. A term set uses hybrids to convert bi-directional transmission on the 2 Wire side, to separate Transmit and Receive paths on the 4 Wire side.

Now that we've got separate Transmit and Receive paths, we can boost the sound level in both directions independently and reduce the possibility of feedback or singing problems so common in 2 Wire devices.

**Illustration/
Explanation:
4 Wire Line Amp
and Signaling
Bypass**



To do this, we use a 4 Wire Line Amplifier. And you can add as many of these as you want wherever needed to keep the voice levels within acceptable limits.

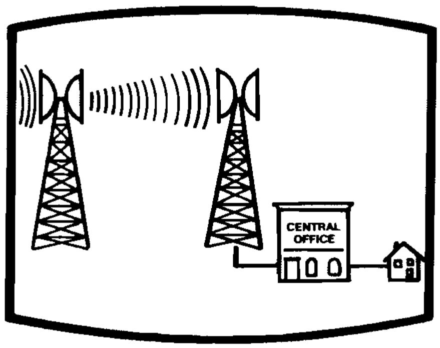
However, signaling information can't go through these transmission devices. The signaling must be split off from the 2 Wire path at the Term Set. And from the 4 Wire path at the Line Amp. This information is recombined to ensure both signaling and transmission get sent simultaneously.

Application: Carrier Facility

Grown men, on opposite sides of the country, Jerry and Tim are still in touch. A sophisticated phone circuit is the one thing that still connects their lives. Except this time, the news isn't being sent over the usual copper wire.

Because this is a transcontinental call, it's traveling by microwave radio. A fairly common conveyance, we call this a carrier facility. The voice transmission is being sent out as a radio signal, traveling across the country from one microwave tower to the next.

Illustration/ Explanation: SF Signaling



Signaling can't be sent directly over microwave carrier. To make it compatible, we have to convert the signaling information into single or multiple frequencies that can be transmitted just like voice.

In Special Services you'll be working mostly with single frequency, SF signaling. These tones are sent right along with the voice, and are amplified along with it too. SF signaling converters are used in many other types of circuits that you'll be handling in the field. Automatic Ringdown and Foreign Exchange to name but two.

Comment

In the next few days, we'll be covering these and other related topics in some detail. As Special Services professionals, you'll be involved with these kinds of circuits regularly. If the discussion gets a little complex, don't worry. Just think back to this brief overview and remember where things fit in the overall telephone scheme of things. It should provide a little perspective to help clarify the training as we go along.

Instructional Objectives

By the end of this text section you'll be able to:

1. Distinguish between on-hook and off-hook phone states and determine whether or not current will flow in each case.
2. Correlate current flow to variances in electrical potential.
3. Rank three sample circuits in order of increasing resistance.
4. Identify level and frequency coordinates for points on a Frequency Response graph.
5. Specify the normal VF bandwidth on a typical POTS circuit.
6. State the Transmission Level Points (TLPs) and the levels of a specified in-band frequency for a circuit containing three amplifiers and a fixed attenuator.
7. Match the components of a telephone circuit to their depictions on a block diagram.
8. Differentiate between the uses of AC and DC in a telephone circuit.
9. Recognize the circuit functions provided by a Central Office.
10. Trace the Transmit and Receive paths on a POTS circuit.
11. Rank a series of four wire gauges in order of increasing resistance.
12. Match a series of facility-related transmission problems to the electrical properties which cause them.
13. Indicate how an alternating current is induced in a transformer.
14. Identify a capacitor in a block diagram and state the reasons for its use.
15. Differentiate between grounded and battery biased Ring Generator and state how Ring Gen biasing affects Tip lead polarity.
16. Match a list of 33 common telephony terms to their appropriate (best) definitions.

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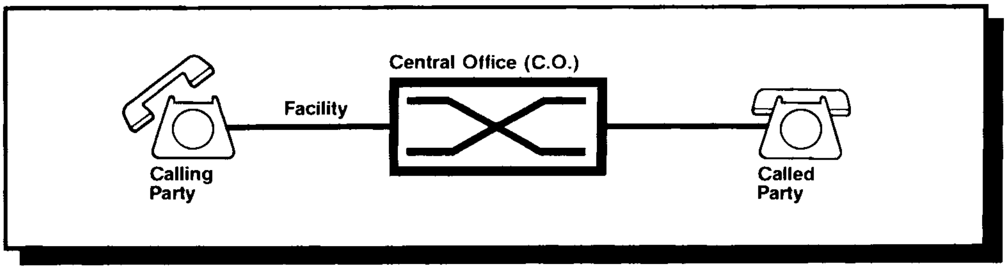
The Circuit



In telephony, sound is carried over an electrical circuit from a calling party through a central office, where it is switched out to the called party.

Circuit Components

There are 3 components to this circuit. A telephone (telset or station), wire cable or other conductor (facility) and the Central Office (C.O.). And we will talk about each in this text section.

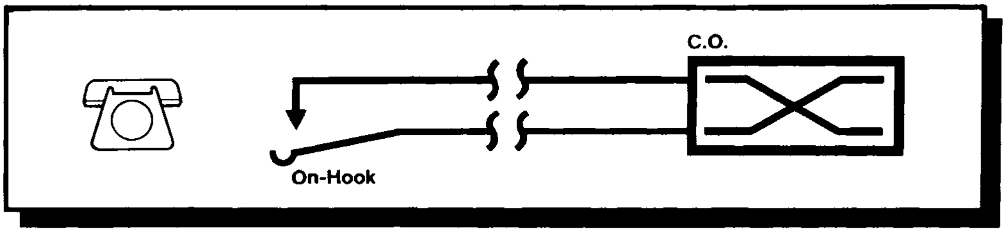
Definition: Current Flow

An electrical circuit requires a continuous flow of electrons (current) from a negative to a positive terminal (battery to ground).

Explanation: Loop Current

A circuit is like a circle or loop. In an electrical circuit, there is conservation of energy. Whatever goes into a device must eventually come out of it.

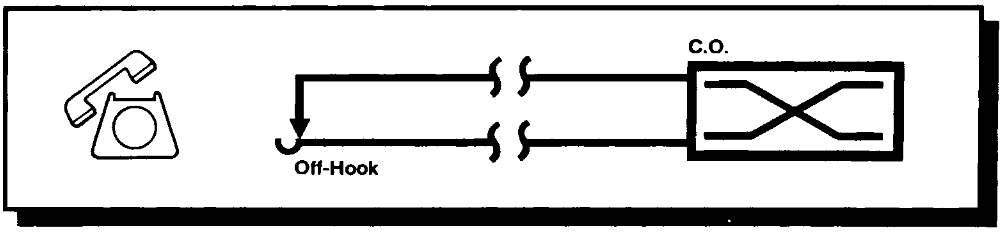
Illustration: On-Hook — Idle



Explanation: On-Hook

When the telephone is on-hook, as in this diagram, the electrical circuit is incomplete. No electrons flow back to the central office.

Illustration: Off-Hook — Busy



Explanation: Off-Hook

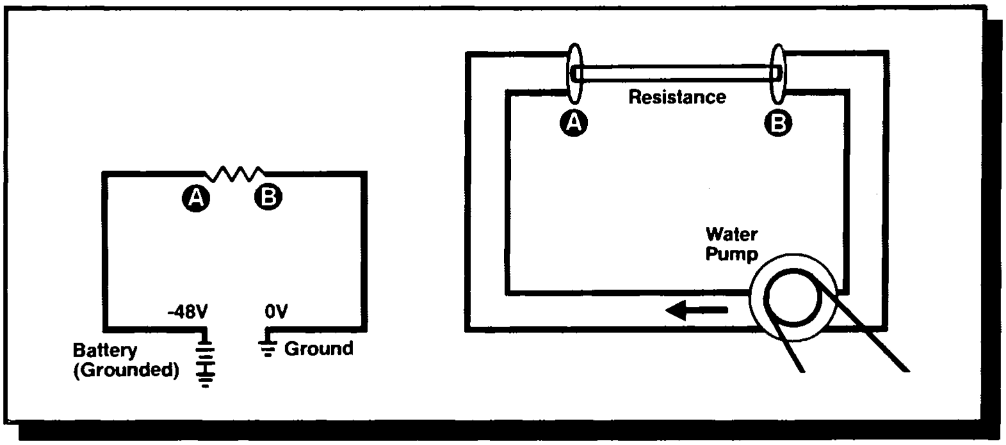
When the phone is off-hook, as in this case, the electron loop is continuous from the central office through the telset, and back to the central office.

Introduction: Electricity

The telephone is powered by electricity. So before we talk any more about communications, let's review a little basic electricity. As you realize, this is a very detailed subject which has been covered in volumes of very thick books.

We're going to try to discuss things briefly without a lot of theory, so that you can get enough background to understand basic telephone electricity without getting swamped by lots of physics equations and derivations that you won't be using regularly on the job.

Illustration: Water vs. Electricity



Explanation: Water Analogy

Electricity can most easily be understood when you think of it in terms of a water pump system. Just as water flows through copper pipes — electrons flow through copper wire.

And just as water seeks its own level, flows from a point of greater pressure to a point of lesser pressure, electricity also flows from a point of greater pressure or potential to lesser potential.

Comment

In the illustrations above, the electrical circuit is like a closed water system.

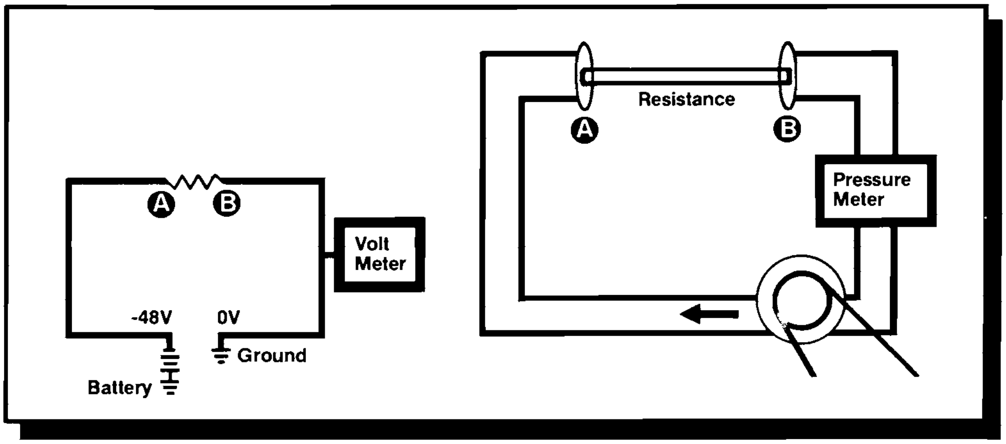
In the electric circuit, some generator, in this case a grounded DC battery, supplies current which flows through a wire conductor. Current passes through a point of resistance, back to the other side of the battery to form a complete circuit.

In the closed water system, a water pump pushes water through a pipe, through a smaller pipe (resistance), and eventually back through the larger pipe to the water pump.

Definition: Voltage/Pressure

Just as water pressure can be measured by a pressure meter, electrical pressure or potential can be measured by a voltmeter. Voltage, then, is a measurement of electrical pressure or potential. And electrical current always flows from a point of greater voltage to a point of lesser voltage.

Illustration: Water vs. Electricity



Explanation: Friction/Resistance

Electrical resistance can also be measured. In the water system example, the amount of resistance created by the small pipe determines the amount of pressure present at Point B.

The longer the small pipe, the greater the pressure drop from Point A to Point B.

In the electrical circuit, the greater the resistance between Point A and Point B, the greater the drop in voltage.

Definition: Ohms

In electricity, the amount of circuit resistance is measured in units called *ohms*. And because circuit resistance increases over distance, in telephony distances are thought of in terms of ohms (abbreviated Ω, the Greek letter *omega*).

Glossary

And to carry the analogy even further:

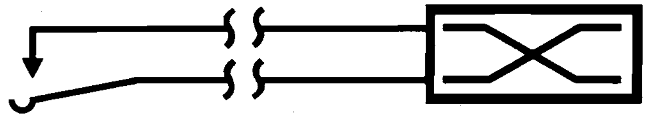
Water	*Electricity*
Pressure	Potential as measured in volts
Flow	Current as measured in amperes
Pipe	Conductor
Pump	Generator/Battery
Valve	Switch
Friction	Resistance

Definition: Amperage

Of the above terms, amperes is one that you'll see again. An ampere is a measurement of the actual current flowing through a conductor. In other words, voltage — potential — pushes amperes through the cable.

Exercise 1

1. In the spaces below each diagram, indicate whether the phone is on-hook or off-hook.



A. Phone is ___________.

_____ Current flows

_____ Current does not flow

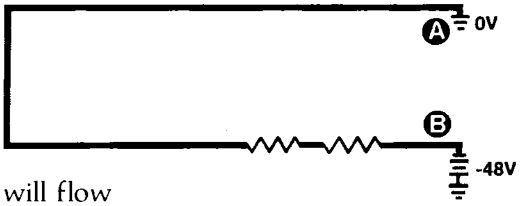
B. Phone is ___________.

_____ Current flows

_____ Current does not flow

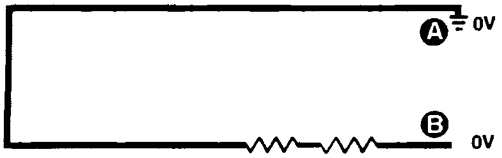
Exercise 2

1. Given the situations depicted below, determine whether current will flow between Points A and B.



A. _____ Current will flow

_____ Current won't flow

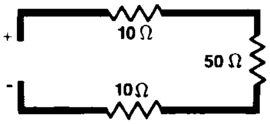


B. _____ Current will flow

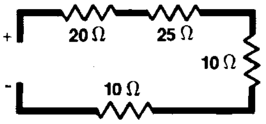
_____ Current won't flow

2. Of the loop circuits shown below, rank them 1-3 (1 is highest, 3 is lowest) in terms of electrical resistance. Remember, series resistances are additive.

A. _____

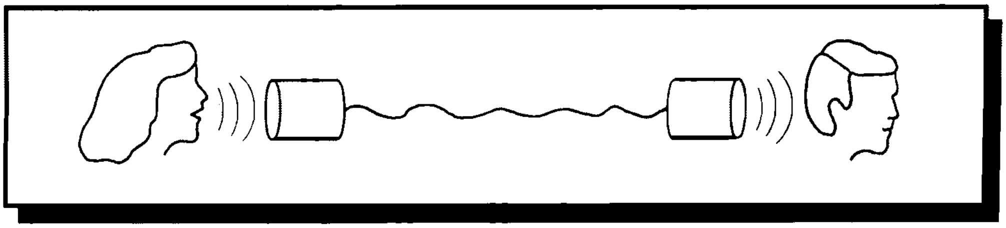


B. _____



C. _____

Illustration:
Sound Waves

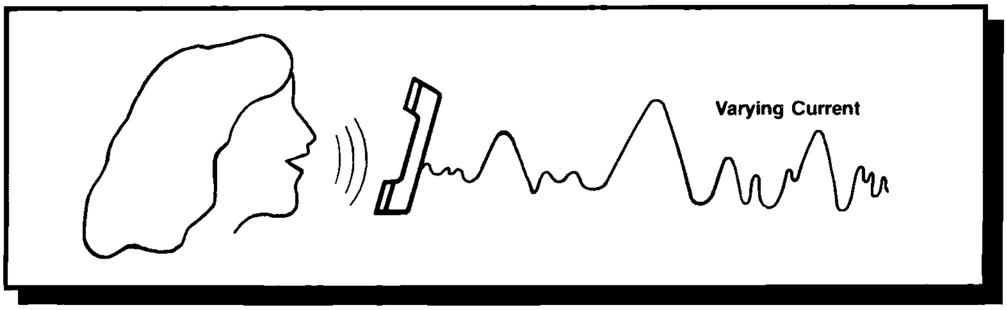


Explanation:
Voice Transmission

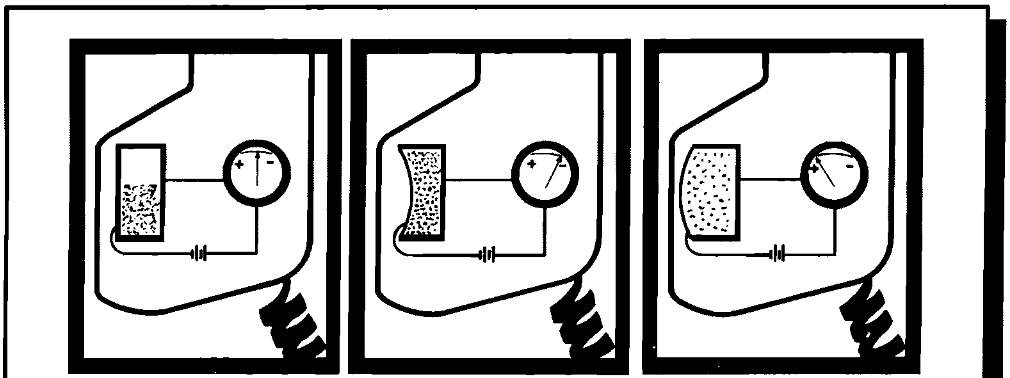
Sound is pressure waves in the air. The human voice causes the tin-can string to vibrate; hence, the receiver can pick up the message.

In telephone transmission, the voice is also carried in sound waves. But these sound waves have been converted to electrical current through the use of the telephone transmitter (microphone).

Illustration:
Voice Transmission



Explanation:
Transmitter



In a telephone transmitter, sound waves push against a flexible diaphragm.

The diaphragm, in turn, pushes against a chamber filled with carbon granules.

As these granules are pushed closer together or allowed to expand, they cause an alternating electrical current (AC) to be generated.

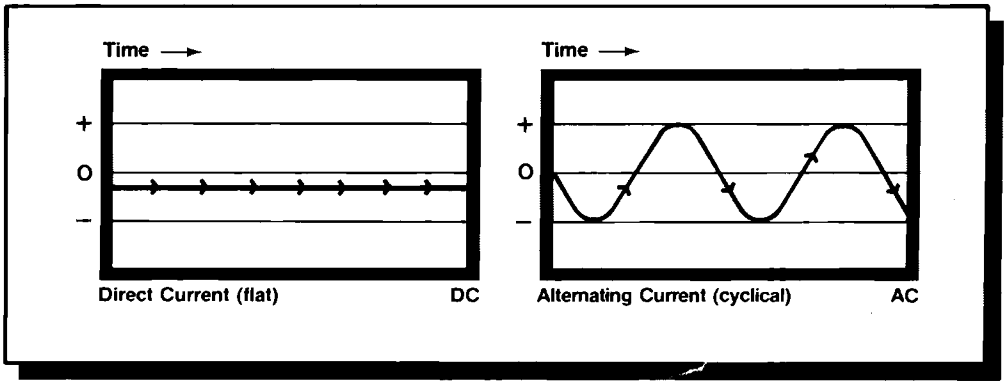
The more the carbon granules are compressed, the more current flows through the transmitter.

Thus, through the compression and expansion of the transmitter's carbon granules, sound waves are converted to a varying electrical current that can be transmitted over copper wire.

Application: AC/DC Current

Both AC and DC current are required to operate a telephone. AC handles voice transmission while the DC takes care of signaling. Without getting too technical, we can show the characteristics of each type of current on a cathode ray tube.

Illustration: AC/DC Current



AC/DC: Definition and Functions

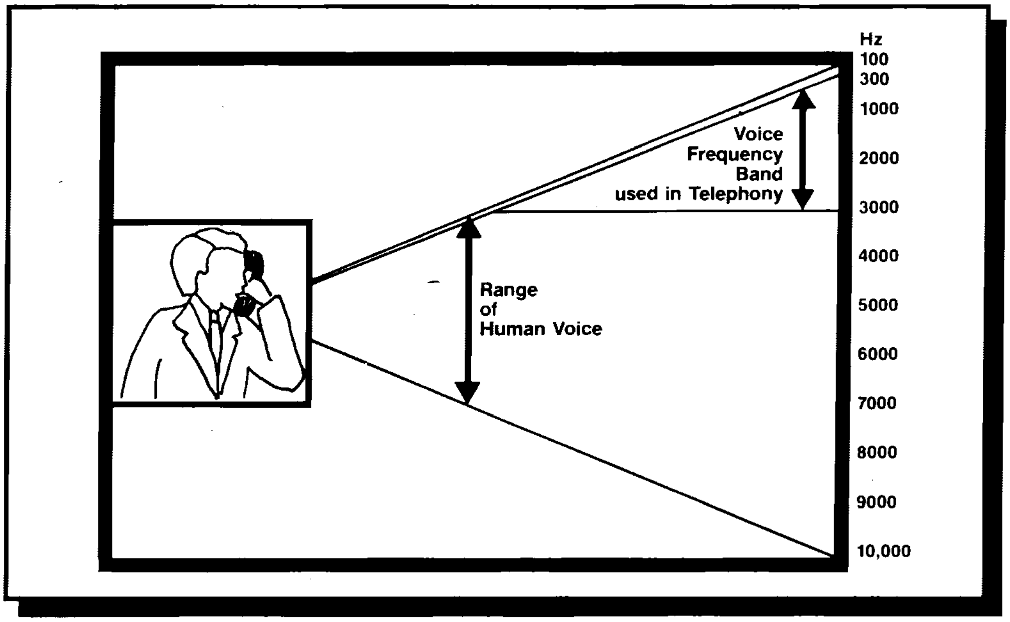
DC or Direct Current is a continuous flow of electrons in one direction only. That's why it looks like a straight, flat line on the oscilloscope. There is no sound associated with DC. This is the current that flows when the phone goes off-hook (busy).

AC or Alternating Current reverses in its direction periodically. Hence, it looks like a wave pattern and each complete wave is a cycle. In telephony, it's meaningful to measure these cycles in terms of their rate of generation — frequency.

Frequency/Hertz

Frequency is measured in units called Hertz (Hz). One Hz is one cycle per second. 30Hz is 30 cycles per second, etc.

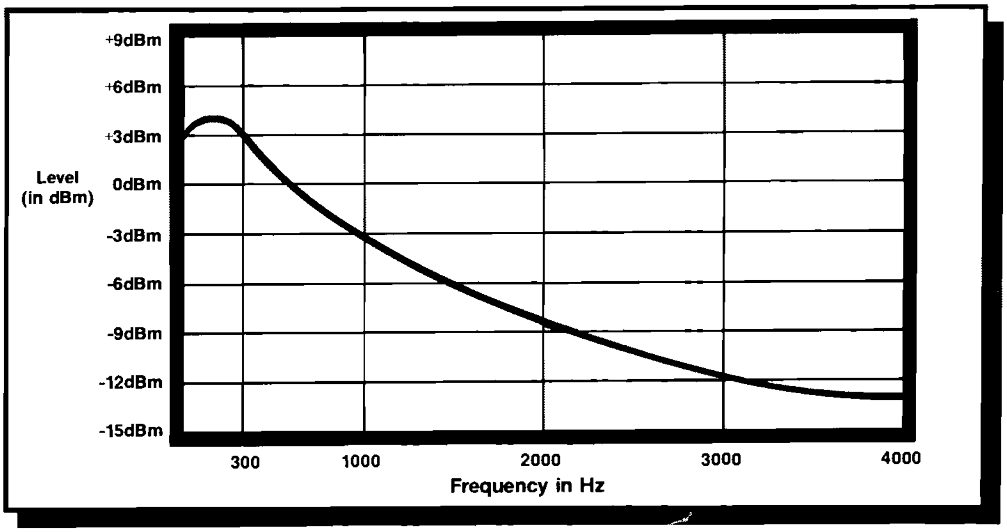
Illustration:
VF Bandwidth



Explanation:
VF Bandwidth

The human voice is capable of producing sound of various tones. These tones vary in both pitch and loudness. Pitch varies the frequency of sound and is measured in Hz. In telephony, the normal voice frequency band is 300-3000Hz. This 300-3000Hz band is used because 90% of all speech intelligence is included in that band.

Illustration:
FR Graph



Explanation:
FR Graph

The frequency response (FR) graph shown above plots pitch or *voice frequency* (Hz) against volume or *level* (dBm).

Application:
FR Graph

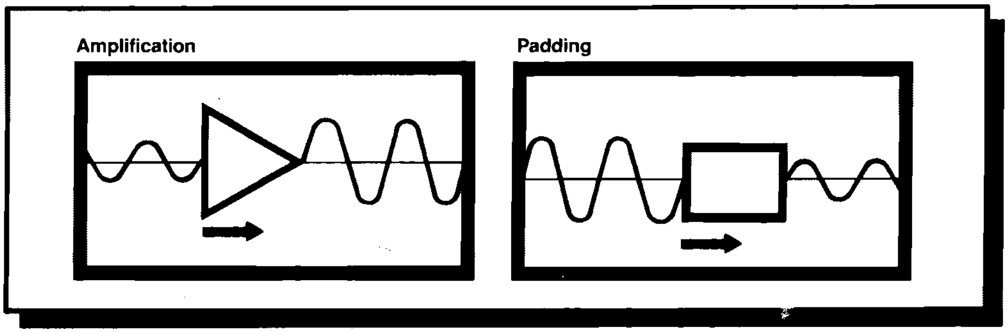
Tones within the standard level and frequency ranges can be transmitted over a telephone circuit, then measured at the other end. This allows you to graph the frequency response of that circuit.

The idea is to make sure that the circuit doesn't alter the quality of the original tones. When you run a frequency response test, all the tones you put into the circuit come out the other side. But the higher frequencies become less audible due to loss.

Adjusting Frequency Response

You can add gain to the circuit via an amplifier to compensate for this loss. Or in some cases, you might add loss through the use of an attenuator or pad. These adjustments are made to improve frequency response, that is, to make what comes out of a circuit match what went in.

Illustration: Amplification/ Attenuation



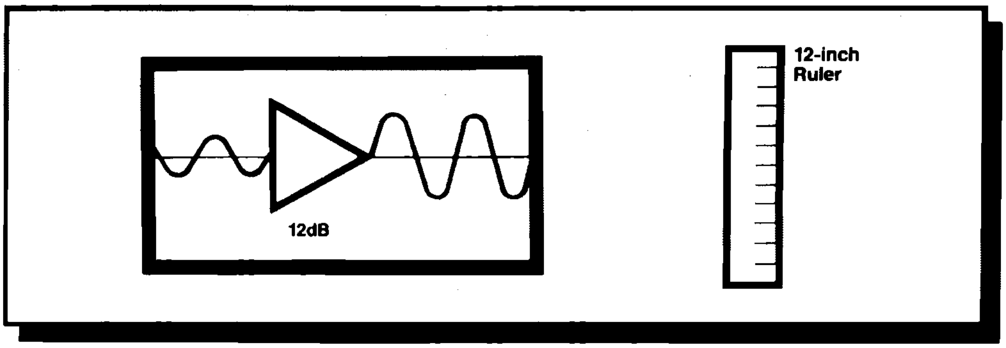
Amplifier provides *gain* to make output power greater than input power.

Attenuator (pad) provides *loss* to make output power less than input power.

Explanation: Amplification and dB

An amplifier can add gain to a circuit. And that gain is indicated by a higher power level. The amount of gain is measured in units called decibels (dB), a logarithmic measurement of the ratio between the input power vs. the output power. (A 3dB gain doubles the power of a circuit. But even though you've doubled the power, the sound is not twice as loud to the listener.)

Illustration: dB

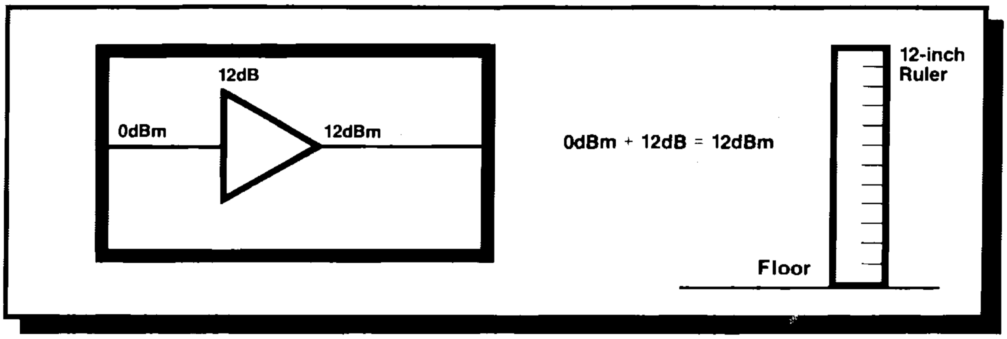


Explanation: dB

A dB is a relative unit of power. It can be applied anywhere, to any AC current. You can think of dB as a measurement of power, just as inches are a measurement of distance. If an amplifier has 12dB of gain, you know the output power will be about 16 times the input power. (For each 3dB of gain, the power is doubled. Thus 12dB gain = 3dB four times. So the power is doubled four times. 2x2x2x2=16.)

But you don't know what the actual output level is unless you know the input level. Similarly, you can use a ruler marked off in inches to draw a line 12 inches long, but if you don't know the starting point of the line, you can't locate the end of it.

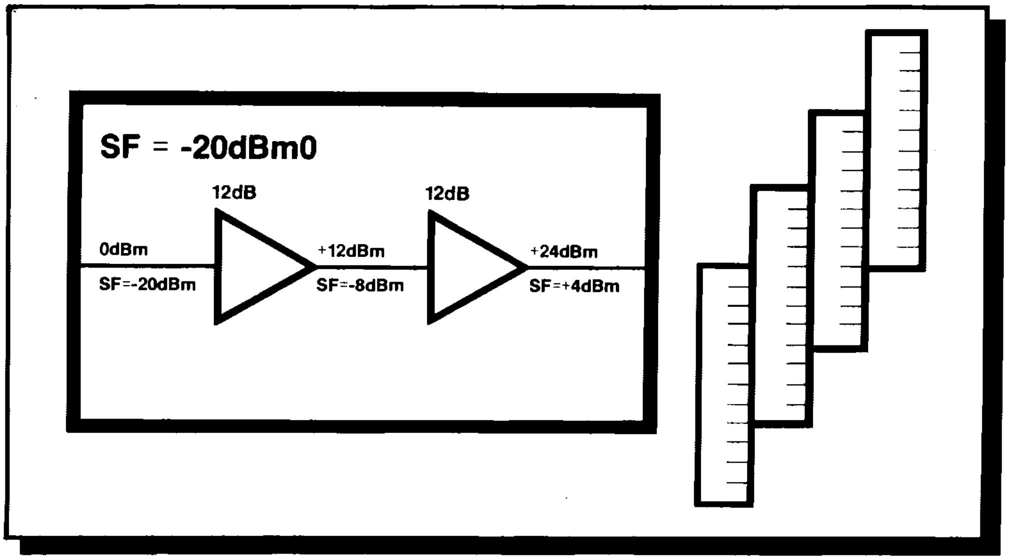
Illustration: dBm



Explanation: dBm

Here, we've referred our 12dB amplifier to an absolute reference point. Our ruler measures 12 inches from a baseline — the floor. And the amplifier's gain is now measured against a standard — 0dBm (or 1 milliwatt across 600Ω). Any alignment levels you set will be measured in dBms.

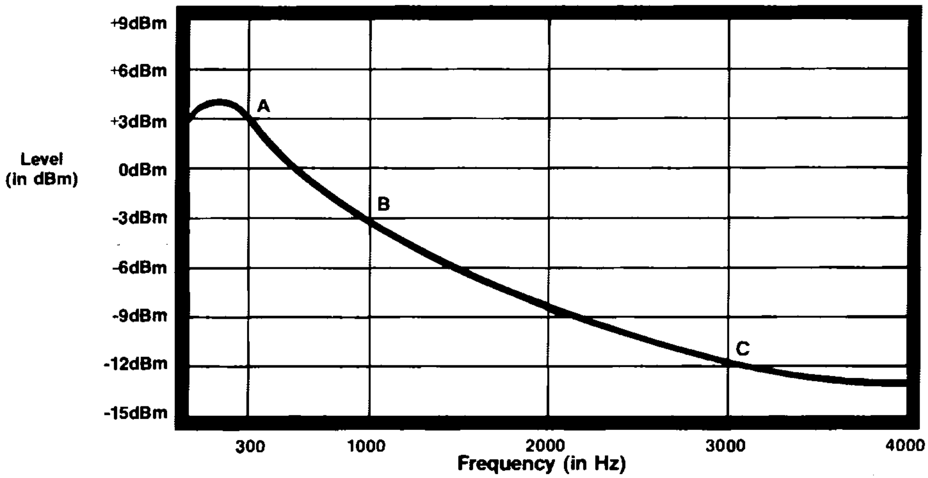
Illustration: dBm0



Explanation: dBm0

You'll encounter installations in which you'll be working with a specific frequency whose level will be set above or below a "normal" alignment level. In this situation, with dBm0, your baseline (alignment level) may change, like the steps in the righthand diagram. But the specific frequency will always remain a constant level above or below your alignment level. SF is 20dB below alignment level or TLP (Transmission Level Point), or -20dBm0.

Exercise 3



1. In the FR graph above, state level and frequency coordinates for the points listed:

   A. ______ Hz, ____ dBm

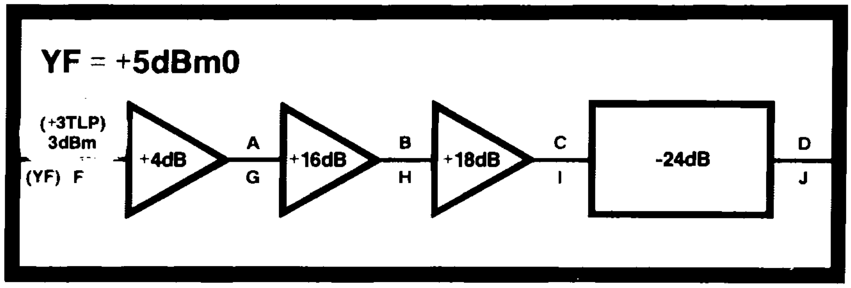
   B. ______ Hz, ____ dBm

   C. ______ Hz, ____ dBm

2. The ordinary VF range of a typical POTS circuit is:

   ______ Hz to ______ Hz.

3.



If a 3dBm signal passes through a series of 4, 16 and 18dB amplifiers and a 24dB pad, what levels would be associated with points A, B, C, and D? How much overall gain or loss would be provided by the various transmission devices? And if an associated tone, YF, of +5dBm0 were also tracked, what would YF's level be at points F, G, H, I and J?

A. ______ E. Overall gain/loss ______

B. ______ F. ______

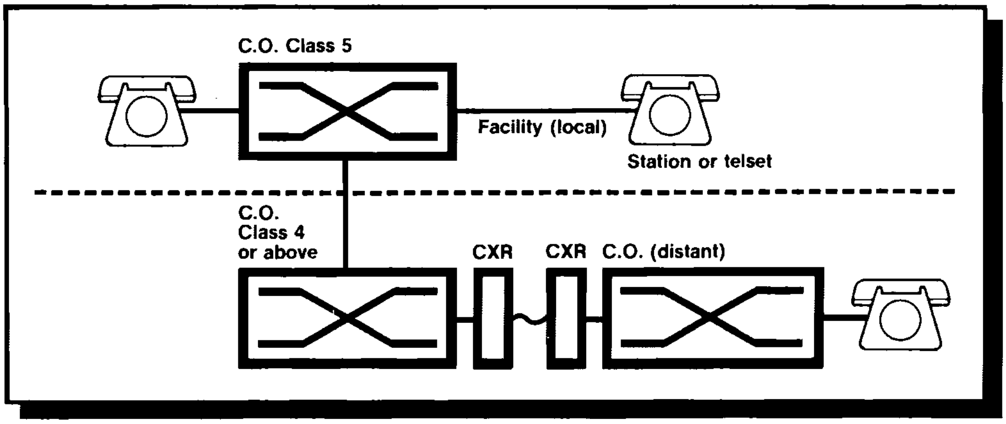
C. ______ G. ______

D. ______ H. ______

I. ______

J. ______

Illustration:
The Basic Circuit



Explanation:
Components

That's enough basic electricity for now. At this point, let's return to the components of the phone circuit. First, there's the telephone, station or telset. Next there's the Central Office or C.O. And finally, there's the transmission facility, usually copper wire, which allows information to be communicated from one point to another.

Components
List

Here we've shown a little more complex example. It includes:

- Two local telephones
- The local Central Office (Class 5)
- A metallic facility to connect the local phones to the local C.O.

- A Toll Grade Central Office (Class 4 or above)
- A Carrier facility (CXR) which could be,
  - Radio
  - Satellite
  - Microwave
  - Fiber Optics
- A distant Central Office
- A distant telephone

Comment

Whether you make a local or a long distance call, the phone/facility/C.O. circuit remains pretty much the same.

Telset Functions

As part of a loop circuit, a phone must perform a number of important functions. It must:

- Convert sound waves to electrical energy (XMT)
- Convert electrical energy to sound waves (RCV)
- Provide signaling information to the C.O.
  - request service by going off-hook
  - provide dial pulsing to identify called party
- Receive signaling or Ringback information from the C.O.
  - receive the various dial tones and busy signals
- Accept power from the C.O. — Talk Battery
- Accept ringing power from the C.O. — Ring Generator

Explanation: Facilities

In POTS, all of these functions take place over a pair of wires (2 Wire facility) which connect the individual telephone to the Central Office.

Application: Uses of AC/DC

The telephone's electrical circuit uses alternating current (AC) to:

- Handle Transmit and Receive functions of voice transmission
- Receive information tones
- Ring the telephone

And direct current (DC) to:

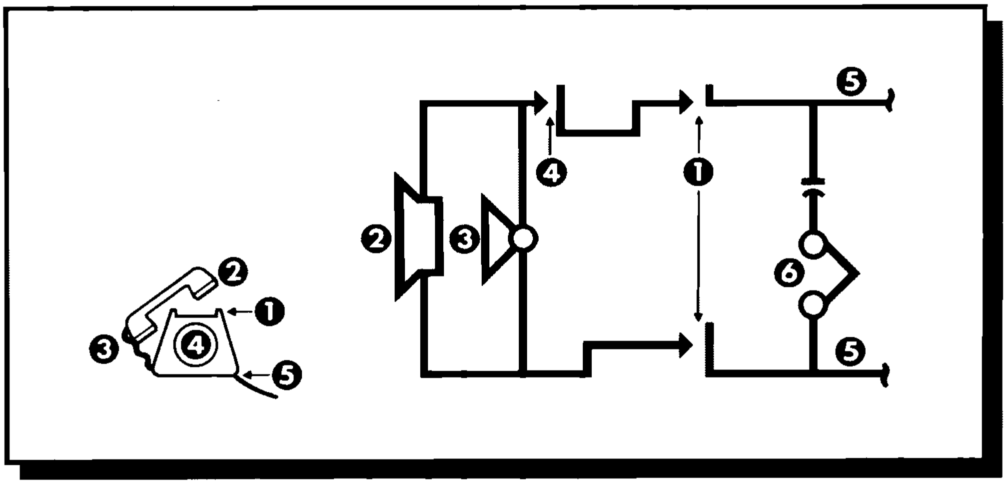
- Provide signaling information
- Power the telephone.

AC/DC Summary

For now, it's sufficient to remember AC is used for all sound transmission (voice and supervisory tones) and rings the phone.

DC provides signaling information and powers the phone.

Illustration: Telset and Block Diagram



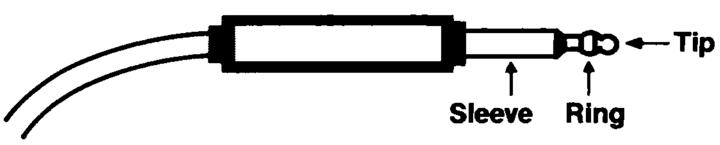
Explanation: Diagrams

These are both diagrams of a telset. The left is the depiction of an installed instrument. The right is a block diagram of the same device.

Telset or Station Components

1. The hookswitch (or switch hook) opens and closes the loop circuit. It controls on-hook and off-hook states.
2. The receiver, like a tiny loud speaker, receives sound messages (either voice frequency or information tones) and makes them audible to your ear.
3. The transmitter, like a tiny microphone, converts your voice to electrical current and allows it to be transmitted to the other party.
4. The dial creates a series of on-hook, off-hook states or pulses which specify for the Central Office the party you're trying to call. When you dial 9, there are a series of 9 circuit opens and closures.

   For pushbutton phones, the buttons transmit a series of dual tone multi-frequency (DTMF) tones which specify the called party.
5. Tip and Ring are the leads that connect the phone to the Central Office. At the C.O., Tip is connected to ground and Ring is connected to battery.



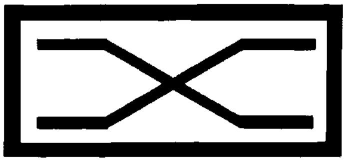
6. The bell or ringer sounds whenever an incoming call is coming through.
7. Not shown in the diagram is a Balance Network, which among other things, provides side tone to allow the speaker to hear his own voice through the receiver.

Review

That's the telset side of the circuit. The other major part of the POTS loop is the Central Office or C.O. The primary purpose of the C.O. is to switch calls from the calling party to the called party. It's not strictly accurate to think of a C.O. as one big switch, but for our general understanding, this conception will help you keep things straight in your own mind.

Introduction: Central Office

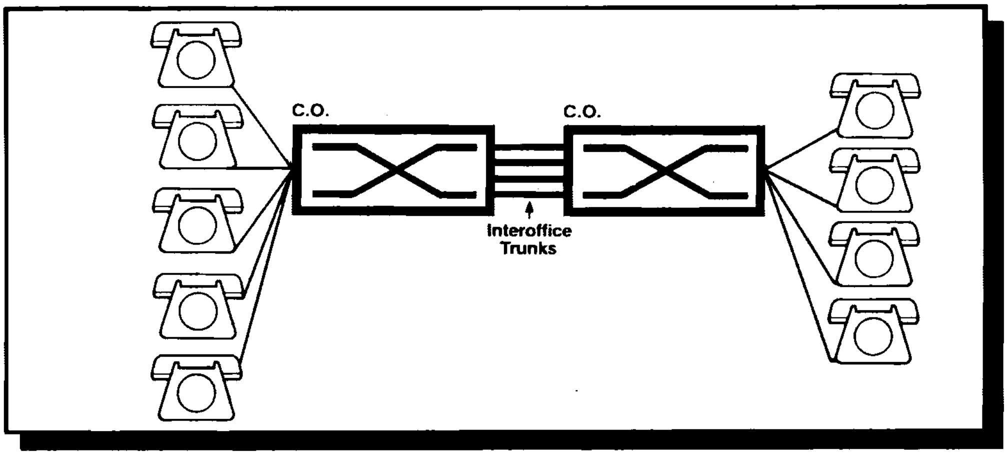
In most parts of this training program, we'll be showing the C.O. like this:



A representation of a switch connecting one line to another, handling hundreds of circuits at super speeds.

But to be truly accurate, we'll have to mention some of the other functions of the Central Office, functions such as providing power, Ring Generator, transmitting supervisory tones and the like.

Illustration:
Central Office



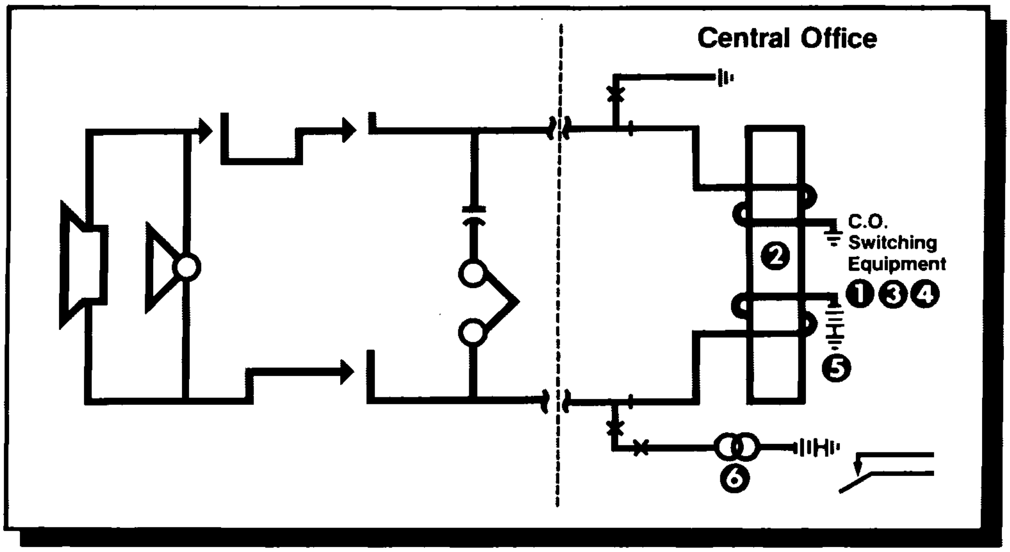
Explanation:
C.O. Functions

Central Offices provide switching and other services to the telephone circuits which are connected to it. Central Offices are usually placed in the center of the area to be serviced.

Comment:
Trunks

Central Offices are connected to each other via interoffice trunks. Trunks are facilities between switches. Regular private telephone lines are, for the most part, dedicated. They're not shared by any other circuit. Trunks are shared facilities and may be accessed by numerous other phone circuits.

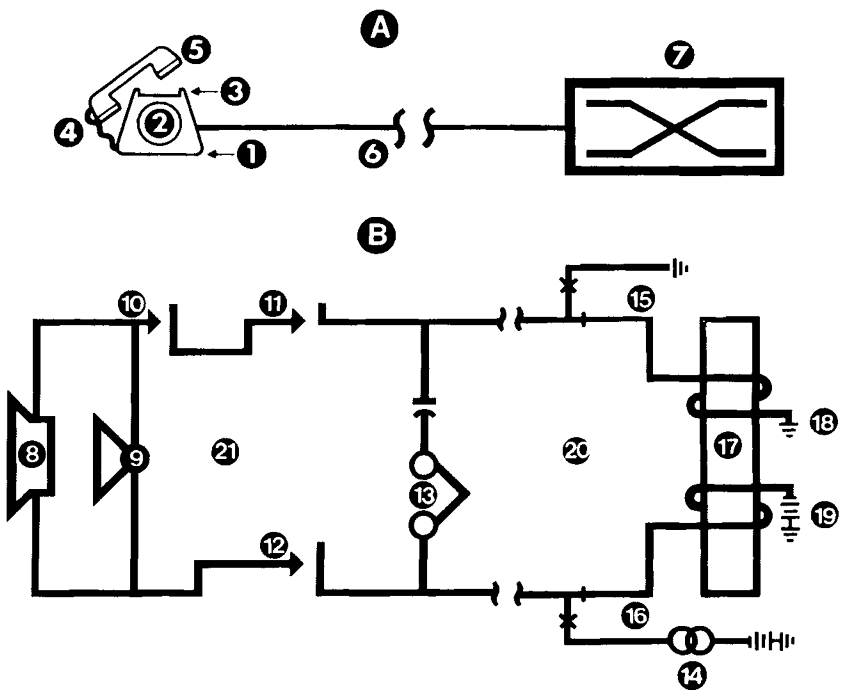
Illustration:
C.O.
Block Diagram



C.O. Components

The Central Office provides:
1. Switching services; call routing to desired parties.
2. Line relay; this is a magnetic controlled loop sense which indicates off-hook status and causes current to flow to the phone.
3. Ringback tones; dial tone.
4. Information tones; busy signals.
5. Talk Battery; the DC power used to activate the transmitter in a telset, thus powering the phone.
6. Ring Generator; AC current to ring phone when called.

Exercise 4



Place the correct numbers from the above diagrams beside the corresponding terms listed below:

A	B						
____	____	____	Tip	____	____	____	Transmitter
____	____	____	Ring	____	____	____	Talk Battery
____	____	____	Ringer	____	____	____	Ground
____	____	____	Line Relay	____	____	____	Hook switches
____	____	____	Telephone	____	____	____	Dial
____	____	____	Central Office	____	____	____	Ring Generator
____	____	____	Receiver				

Exercise 5

1. In POTS service, AC current is used for ______________________________
____.

2. In POTS service, DC current is used for ______________________________
____.

3. Place an "X" beside each item that is usually provided at a typical Central Office.

_____ Dial pulsing

_____ Talk Battery

_____ Loaded cable

_____ Power (for the phone)

_____ Off-hook

_____ Loop current sensing (Line Relay)

_____ Ringback signals (dial tone and ringing signals)

_____ Information signals (ringing, busy)

_____ Ring Generator

_____ Ringing (Bell)

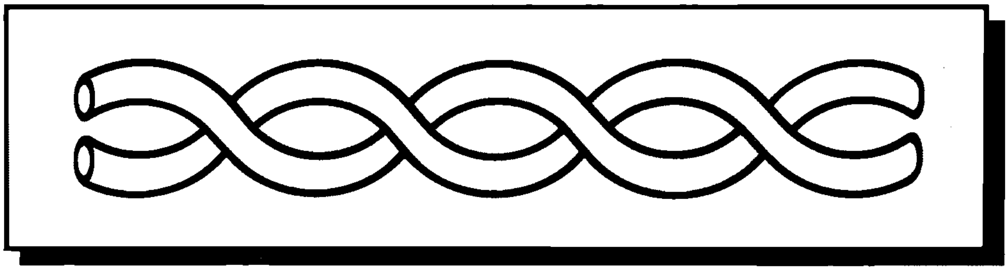
_____ Switching

_____ PBX

Introduction: Facilities

The third part of our POTS telephone circuit is the 2 Wire copper cable facility which connects the telephone to the Central Office. In other applications, other types of facilities can be used. For example, there are 4 Wire facilities and Carrier facilities which we've already touched upon. For now though, we'll look at the 2 Wire cable pair used in POTS service.

Illustration: Cable Pair



Explanation

In POTS service, all transmission and signaling information is carried over two copper wires — a telephone cable pair.

Comment: Tip and Ring

One of the conductors is referred to as Tip and it's connected to ground at the Central Office. The other conductor is called Ring, and it's connected to battery also at the Central Office.

Bi-Directional Transmission

In POTS service, transmission is bi-directional. That means it takes place in both directions simultaneously. Since transmission travels over the complete 2 Wire circuit, both Transmit and Receive functions are carried over Tip and Ring.

Wire Gauges

Since telephones operate over various sizes (gauges) of copper wires, it's important to understand some of the electrical characteristics of these wires. Especially when you realize that some common telephone performance problems are related directly to these facility characteristics.

Explanation: Conductance

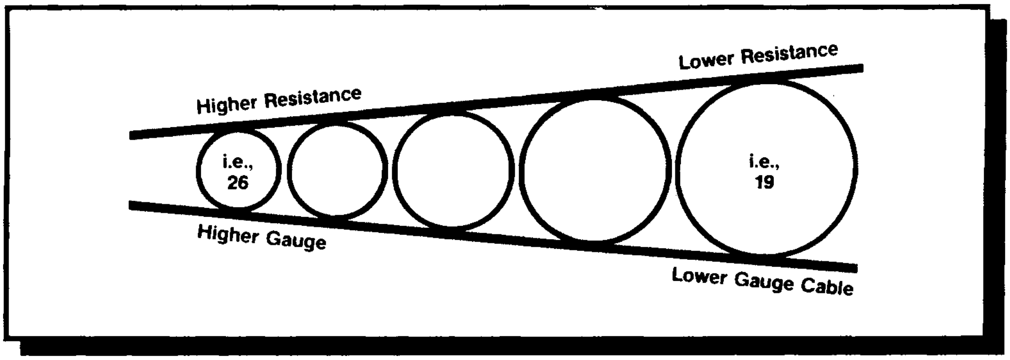
Some materials conduct electricity more efficiently than other materials. Gold and silver are the best conductors around. But they're very expensive and hard to work with. Copper is close in conductance, and it's in a more feasible price range for widespread use.

Definition: Conductance/ Resistance

You can think of electrical conductance as the opposite of resistance. The better the conductor, the less electrical resistance.

Also, electrical resistance increases as wire diameter decreases. And resistance also increases as circuit length increases.

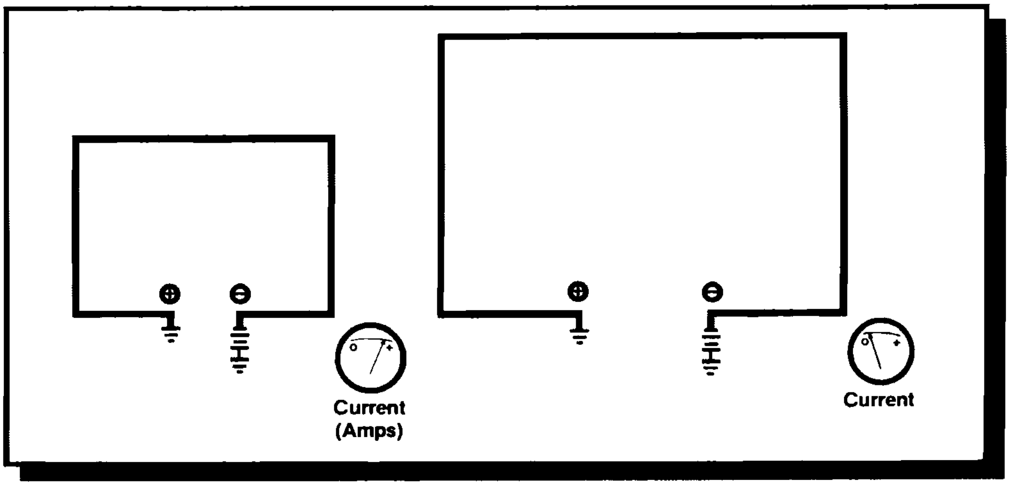
Illustration: Resistance vs. Gauge



Comment

It's easy to remember these characteristics when you think of the water pipe example. The smaller the diameter of the small pipe, or the longer its length, the more resistance would be present in the system.

Illustration: Resistance vs. Distance



Given identical input power and wire gauge.

Comment

Due to the nature of electricity, you can expect some problems in the telephone performance which are caused by facility characteristics themselves.

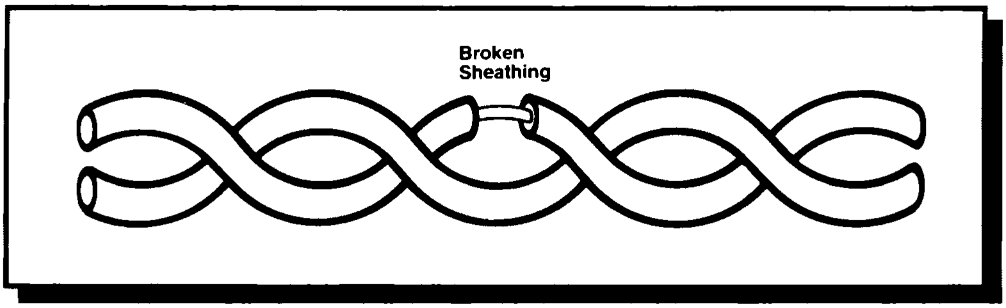
Attenuation

The longer a circuit loop, the more power loss you can expect over the length of the loop. This loss is called attenuation.

Resistance/Friction

This is easily understandable if you remember our water system example. The friction (resistance) present in the small pipe will reduce the water pressure at the distant end of the pipe. And the longer the pipe, the greater the drop in pressure.

Illustration: Unbalance



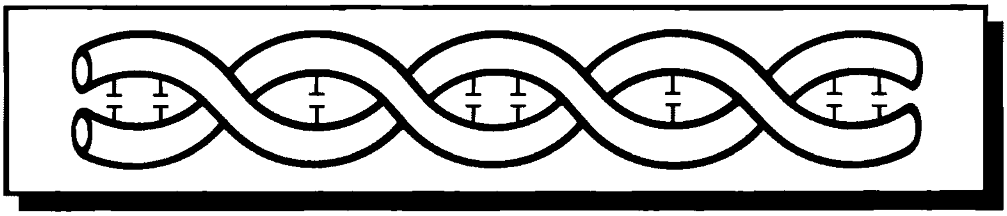
Explanation: Unbalance

Although signaling leads or Ring Generator may be physically grounded, transmission problems can result when one of the cable pairs is inadvertently connected to ground. This causes an unbalanced condition.

Unbalance Problems

When the sheathing or wire insulation is worn or broken in a certain spot, a ground condition may develop. This condition can cause increased impulse noise, AC hum or other unwanted circuit noise.

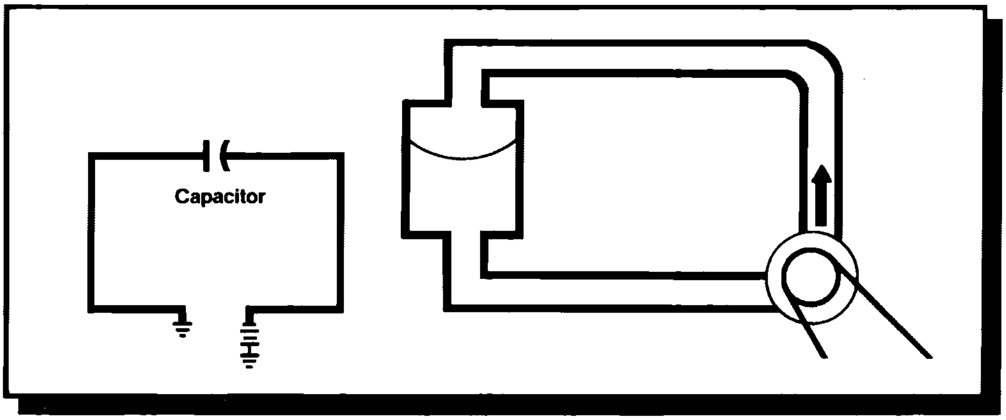
Illustration: Capacitance



Explanation: Capacitance

Another facility problem that you will continually run into is distributed capacitance. The problem is indicated by a loss of AC power over distance, and it must usually be compensated for in most long haul installations.

Illustration: Water System Capacitance

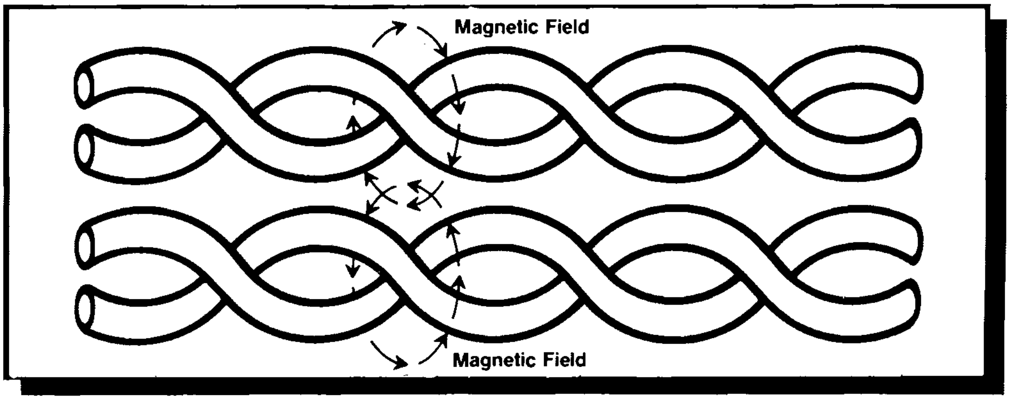


Explanation: Capacitor Functions

To illustrate capacitance, we've installed a rubber diaphragm into our closed water system. As we start the pump, water flows in one direction until it reaches the diaphragm. At first surge, the diaphragm flexes but it allows no water to pass. Eventually some equilibrium is reached and the pressure exerted by the diaphragm equals the pressure exerted by the pump. In this case, nothing moves. The one-way pump is like DC current.

With a two-way pump which changes directions, we can equalize the pressure on either side of the diaphragm. By pumping water first one way, and then the other, water continues to move through the system despite the effects of the diaphragm. This is a situation akin to AC. Hence, capacitance (or a capacitor) blocks DC but allows AC to pass.

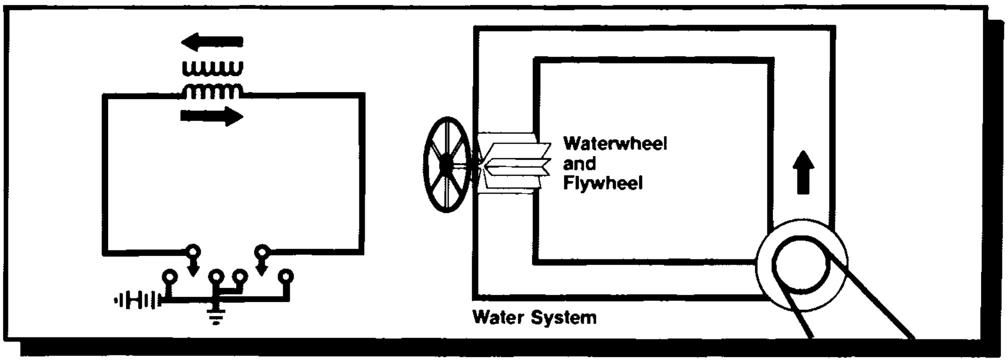
Illustration: Inductance



Explanation: Crosstalk

When electricity passes through a conductor, a magnetic field is created around that conductor. As the current in the conductor varies, the strength of the magnetic field varies too. If the magnetic field crosses another conductor, it causes an opposite current flow in that conductor. This is inductance. And it's the principle behind all electrical transformers. It's also the cause of a fairly common facility-related problem: crosstalk. Crosstalk occurs when one cable pair induces a current in another pair. The result is the superimposition of one circuit — or phone conversation — onto another.

Illustration: Water System Inductance



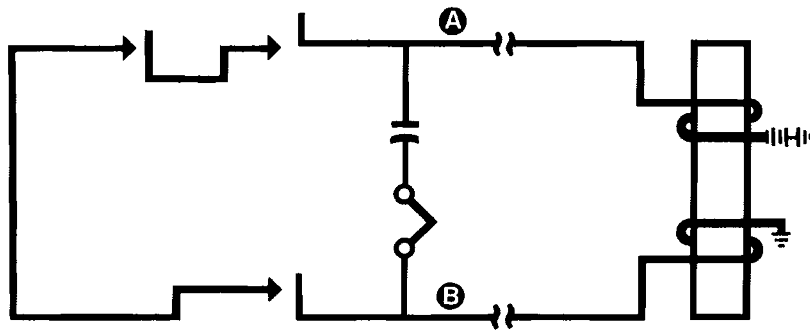
Explanation: Transformer Windings

You can think of inductance in terms of the water system analogy we used before. We've installed a water wheel and connected flywheel into the system. With water pumped in one direction, the water wheel would at first be reluctant to turn, slowed by the inertia of the heavy flywheel. Eventually, as pressure increases, the water wheel will pick up speed and begin turning smoothly. The free-flowing water is like DC.

If you stop the pump, the water wheel's momentum, tied to the heavy flywheel, will keep the water running until the mechanism eventually slows to a stop.

However, if you were able to adjust the pump's motor to consistently reverse directions, the water wheel would never turn. This reversal of direction is like AC current. Hence, inductance (or an inductor) passes DC current but stops AC. In a transformer (like the one at left) there are two coil windings with equal numbers of turns in each. In transformers, AC in one coil creates a magnetic field which induces an opposite current flow in the other winding.

Exercise 6



1. In the spaces below, correctly indicate the letter which corresponds to that component on the diagram above.

   _____ Tip lead

   _____ Ring lead

2. In the spaces below, correctly indicate which of the above components handles the transmission functions described.

   _____ Transmit (XMT) path

   _____ Receive (RCV) path

3. Place an "X" beside the statement(s) below that are correct:

   _____ In a 2 Wire circuit, Transmit and Receive functions are carried on different transmission paths.

   _____ In a 2 Wire circuit, Transmit and Receive functions are carried on the same transmission path.

   _____ In a 2 Wire circuit, transmission is bi-directional.

4. Rank from 1 to 4, with 1 lowest and 4 highest, the following wire gauges in order of increasing resistance.

   _____ 26 gauge

   _____ 19 gauge

   _____ 22 gauge

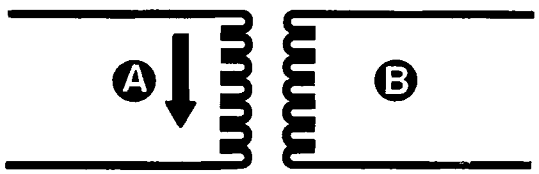
   _____ 24 gauge

Exercise 7

1. Cable facility characteristics can cause some basic phone problems. From the list of problems at the left, match the probable causes in terms of these general characteristics:

_____ Power loss	A. Oscillation
_____ Crosstalk	B. Inductance
_____ Induced noise (AC hum, impulse noise)	C. Resistance
	D. Unbalance

2.



Given the arrow-indicated current in winding A, explain which direction current will travel in winding B? ______________________________

____

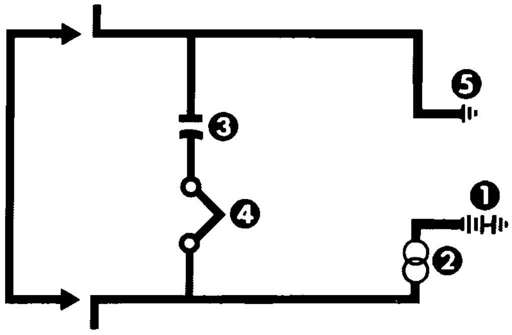
What type of current will be involved on the B side? ______________

____

What principle of electricity is involved here? ______________

____

3.



Which number corresponds to the capacitor in this diagram? __________

What purpose does the capacitor serve in this circuit? ______________

____

Overview

The ringing of the telephone puts together many of the concepts and principles we've mentioned already. We do intend to describe the process in some detail in just a few moments. But before we start, let's just mention the two most important engineering problems that are confronted during phone ringing.

Explanation

First off, a relay is activated and the phone starts ringing. The hard part is to make sure that the phone stops ringing when the phone goes off-hook. As you'll see, that's not as easy as it may first seem.

Secondly, it's imperative that no DC go through the signaling loop until the called phone actually goes off-hook. If DC does go through, then the C.O.'s line relay would route the call even though the phone itself was still on-hook. We definitely don't want this to happen.

Comment

In reading the next few pages, just keep these problems in mind.

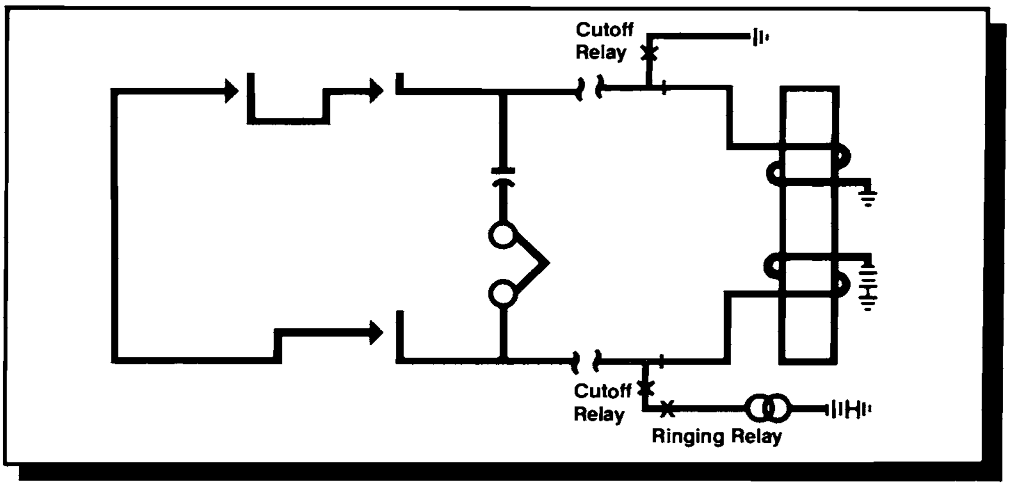
1. The phone should stop ringing as soon as it goes off-hook. If it doesn't Ring Trip, a high voltage Ring Gen current could very seriously harm the listener's ear.
2. No DC current should activate the Loop Sense circuitry until the phone actually goes off-hook.

These two considerations will help give you some perspective for understanding the discussion that follows.

Introduction: Ringing

Finally, let's see how all these pieces fit together to actually ring a telephone. Often, it's hard to visualize exactly what's going on when the telephone rings. First we'll walk you through that process and then we'll talk about some of the installation problems you might face when working with these circuits.

Illustration: C.O. Relays and Ring Generator



Review

We stated earlier that AC current, originated at the C.O. by the Ring Generator, rings the telephone. At the same time, DC current passes through the circuit providing power for such functions as Talk Battery and loop signaling.

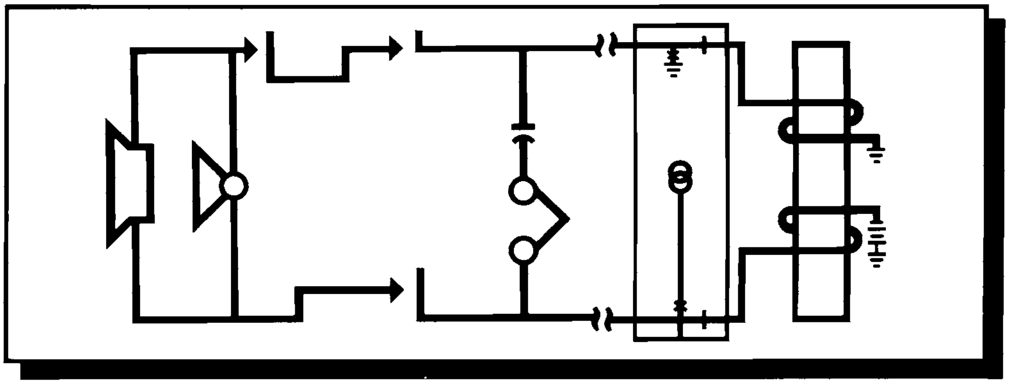
Ringing Procedure

When everything is working right, the telephone rings, the called party goes off-hook, the ringing stops instantaneously, and the call goes through.

How Ringing is Generated

When a call comes through the switch, a Cutoff Relay and a Ringing Relay are activated at the Central Office. This causes the Ring Generator to apply voltage for the standard 2 seconds on/4 seconds off ring cycle. The Ring Gen applies a nominal 105V AC at 20 to 30Hz, causing a current sufficient to ring the telephone.

Illustration:
No Ring Trip

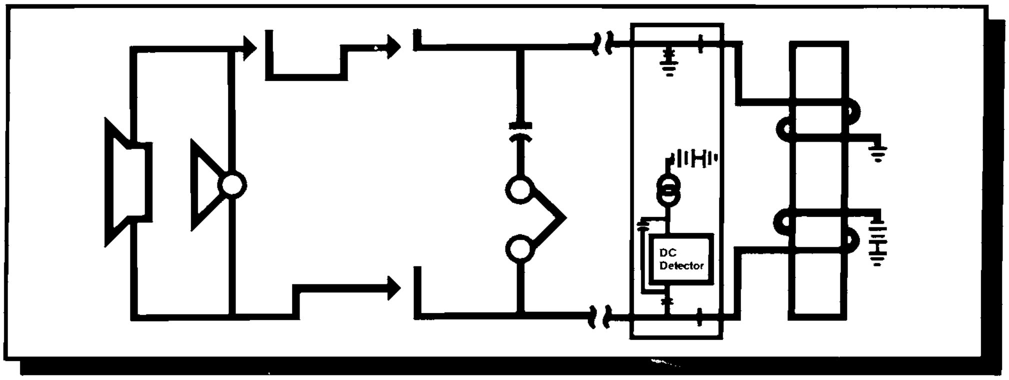


Explanation:
No Ring Trip

If set up in this configuration, we could certainly get the telephone to ring. AC Ring Gen will go through the facility to the telephone's ringer. The capacitor there will prevent DC flow, but the AC will definitely ring the phone — 2 seconds on/4 seconds off.

When the phone eventually goes off-hook, DC current will flow through the hand set, thus powering the transmitter. But without any special DC detection circuitry, the phone will keep ringing indefinitely. As we said before, this 105V AC could severely damage the listener's ear. The solution to the problem is two-fold. On one hand, you build in some DC detection circuitry to de-activate the relays. And on the other, you bias the Ring Generator to either ground or battery.

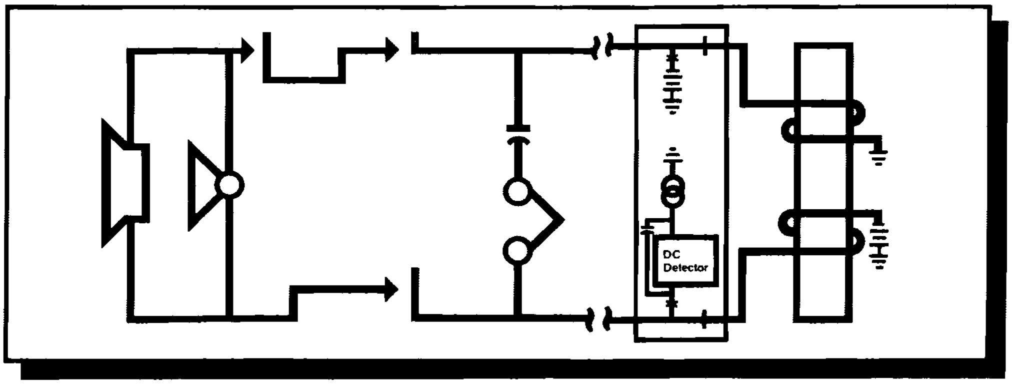
Illustration:
DC Detection



Explanation:
DC Detection

Here we have added some DC detection to Ring Gen configuration. The DC detector notices loop closure and de-activates the relays. In a Central Office application, the detection circuitry would vary depending upon the type of C.O.

Illustration: Grounded Ring Generator



Explanation

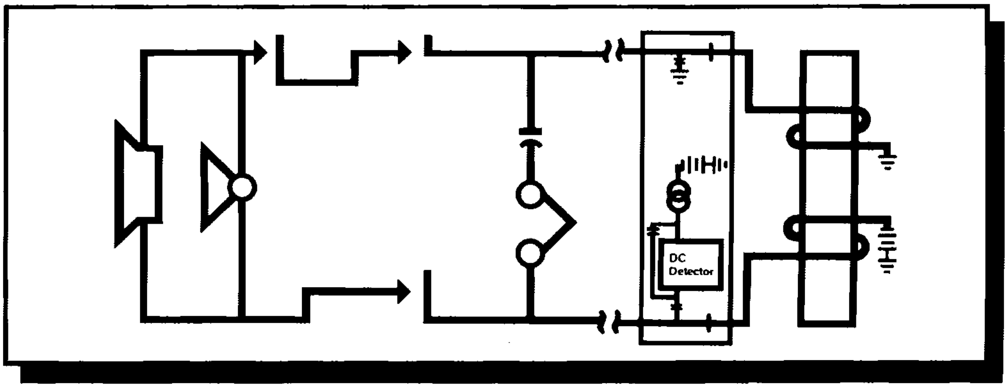
In Special Service circuits DC detection is only one step in achieving Ring Trip. The other aspect is the biasing at the Ring Gen (on the Ring lead), connecting it directly to ground. In the case of grounded Ring Gen, we must connect the Tip lead to battery.

Comment

With a grounded Ring Gen, the 4 seconds off period is referenced at 0V.

Most Ring Trip problems occur because the Ring Gen and the Tip side are not connected to opposite polarities.

Illustration: Battery Biased Ring Gen



Explanation

Here we've got the Ring Gen connected directly to battery. This is the most common configuration that you will run into. But with the Ring Gen connected to -48V, the other side of the circuit must certainly be connected to ground.

Note

This seems to be an exceedingly simple point to keep making. But most Ring Trip problems in Special Service circuits — when the phone keeps ringing or the call does not go through immediately — are due to the incorrect or non-existent biasing of the Ring Gen.

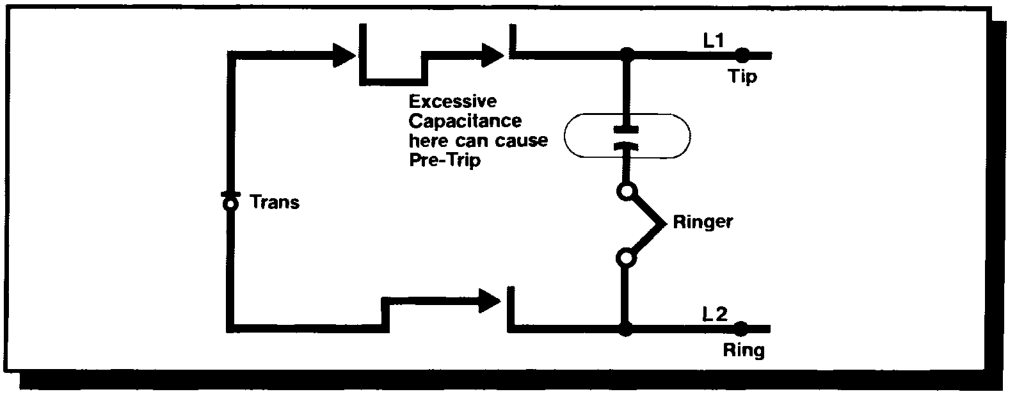
In this instance, as in all of electricity, it is essential to remember:

If one side of a circuit is connected to battery, the other side of the circuit is connected to ground. This simple principle, so often taken for granted, is the source of endless trouble calls from field installers.

Comment

In the case of battery biased Ring Gen, the 4 second off period is referenced to a -48V.

Illustration: Pre-Trip



Note

One other common facility problem figures into the telephone/Ring Trip circuit. It's the second most common cause of Ring Trip problems — right after incorrectly biased Ring Generator.

Pre-Trip

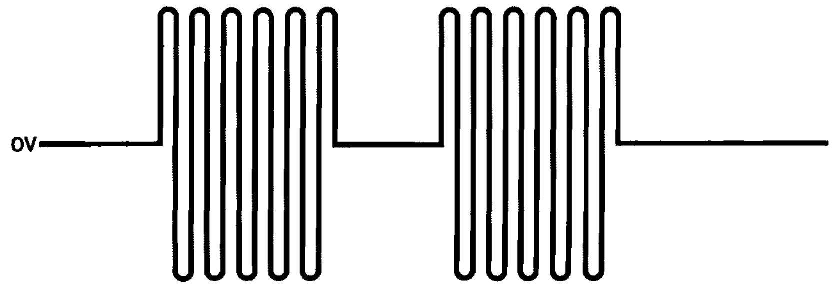
When there's too much capacitance built into the circuit, or if DC current is otherwise allowed to pass through the loop, it can cause premature Ring Trip, or Pre-Trip.

Comment: Telset Capacitance

Pre-trip occurs at the first surge of electricity at the first ring of the phone. Excessive capacitance will look like a short. This will be sensed at the DC detector and will cause premature Ring Trip. If you're experiencing pre-trip, check the capacitor wiring in the phone instrument. It's likely to be the source of the problem.

Exercise 8

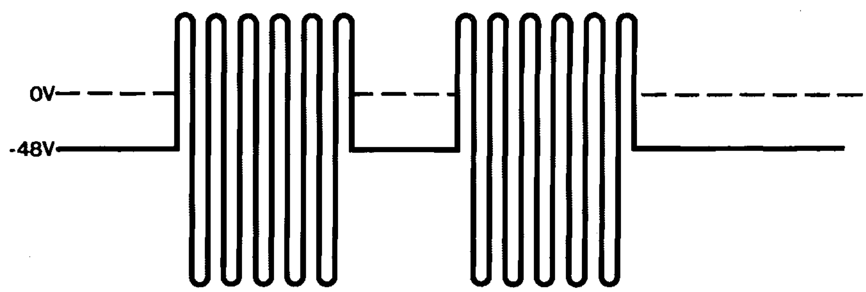
1.



A. This is ☐ Battery-Biased ☐ Grounded Ring Generator.

B. With this configuration, Tip side must be connected to ________________.

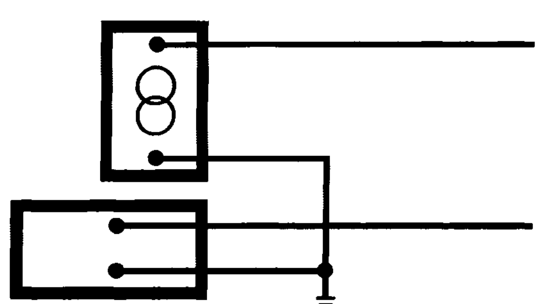
2.



A. This is ☐ Battery-Biased ☐ Grounded Ring Generator.

B. With this configuration, Tip side must be connected to ________________.

3.



With this Ring Gen configuration, the other side of the circuit must be connected to ____.

Comment

You've covered a lot of information during the preceding 34 pages. It might have been a little basic in some areas, perhaps initially unclear in others. Either way, we hope it wasn't too painful.

Basic Vocabulary

It's important that we finish this text section understanding the fundamentals of POTS service. Almost everything else in this training will build on this foundation.

Review

There are three basic parts of the telephone circuit. Station, Central Office, and Facility.

Both AC and DC current are used in the circuit to provide transmission of voice and supervisory information, and to provide signaling information such as off-hook and dial pulsing states.

In POTS service, transmission is bi-directional. Both Transmit and Receive paths are carried over the same telephone cable pair.

Comment

These are the very basics. We've explained these processes by introducing a lot of terms. Some of them you probably already knew, but some may have been new to you. The final quiz for this section will ensure that we all share the same vocabulary. It'll also mean that we won't have to go back to re-explain the same material at each stage.

Directions

Review any sections that you feel unsure about. Then go on to Exercise 9 for a review of terms.

Exercise 9

In the space at the left, preceding the telephony term, place the letter which responds to the best definition in the right column.

Since some of the terms are synonyms, some of the definitions will be used more than once.

_____ 1. Hz
_____ 2. -20dBm0
_____ 3. Line Relay
_____ 4. Tip polarity (what it's connected to)
_____ 5. Ring polarity (what it's connected to)
_____ 6. Battery
_____ 7. Ground
_____ 8. 2 Wire circuits
_____ 9. Ring Trip
_____ 10. Off-hook
_____ 11. Pulsing
_____ 12. Information tones
_____ 13. On-hook
_____ 14. Loop
_____ 15. dB
_____ 16. Signaling
_____ 17. Capacitor

A. 
B. Station-C.O. POTS connections
C. Closed loop — current flows
D. Measurement of non-referenced power or level
E. DC detector which stops ringing
F. Relay which responds to off-hook status
G. Procedure for indicating to the receiving end of a circuit, that intelligence is to be transmitted.
H. Series of open/closed loop states
I. Flat, one-directional current
J.  or 
K. Dial tones & busy signals
L. 300-3000Hz
M. Measurement of AC cycles/second
N. Open loop — no current flow
O. Passes AC, blocks DC
P. Passes DC, blocks AC
Q. Tone transmitted below alignment level

Exercise 9 (cont'd.)

In the spaces at the left, preceding the telephony term, place the letter which corresponds to the best definition in the right column.

Since some of the terms are synonyms, some of the definitions will be used more than once.

_____ 1.	AC	
_____ 2.	Facility	
_____ 3.	Ampere	
_____ 4.	Volt	
_____ 5.	Talk Battery	
_____ 6.	Level in dBm	
_____ 7.	Line relay	
_____ 8.	DC	
_____ 9.	Station	
_____ 10.	C.O.	
_____ 11.	DTMF	
_____ 12.	Resistance	
_____ 13.	Ohms	
_____ 14.	Ring Generator	
_____ 15.	Frequency Response	
_____ 16.	VF Band	

A. Source of 105V AC current

B. 300-3000Hz

C. Comparison of pitch to volume

D. Measurement of electrical potential

E. Central Office

F. Medium over which current is carried

G. Closed circuit

H. Pushbutton dialing

I. Friction within a circuit

J. Crosstalk

K. Measurement of electrical resistance

L. Cyclical current changing directions

M. Loop Sense which responds to off-hook status

N. Measurement of volume or power as related to 0dB

O. Flat, one-directional current

P. Bi-directional transmission

Q. Power source to the telephone

R. Measurement of current at a point in the circuit

S. Installed telephone instrument

Tellabs

Section 3: Extended Circuits

Instructional Objectives

By the end of this text section you'll be able to:

1. Distinguish between the Frequency Response graphs for loaded and non loaded cable.
2. Match each of a list of circuit applications with its characteristic impedance.
3. Identify the cause of 2 Wire Return Loss and recognize its effect on telephone performance.
4. State the purpose, usual location and primary limitation of a Loop Extender.

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Explanation: Attenuation

Some of the inherent characteristics of telephone cable cause performance difficulties as the circuits are extended over distance. Increased electrical resistance along with Shunt Capacitance, Capacitive and Inductive Reactance, and the Skin Effect Phenomena cause some loss of power. The loss, or attenuation, is greater over longer distances.

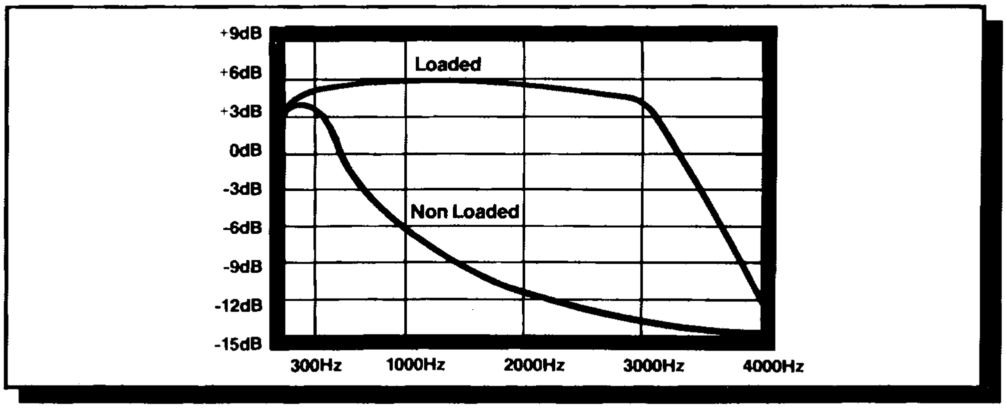
Comment

We don't think you have to know all about the physics of electricity — or memorize a lot of formulas and equations — to understand this basic concept. You can learn more from many excellent books on the subject. We're only trying to make a very basic point. As a result of many factors, telephone transmission quality will necessarily deteriorate over distance.

Application: Loading Cable

Most affected by attenuation are the higher frequencies in the 300-3000Hz voice band. In order to prevent the attenuation of these frequencies, we *load* the cable; that is, we add inductance via loading coils, at regular intervals to cancel the capacitance.

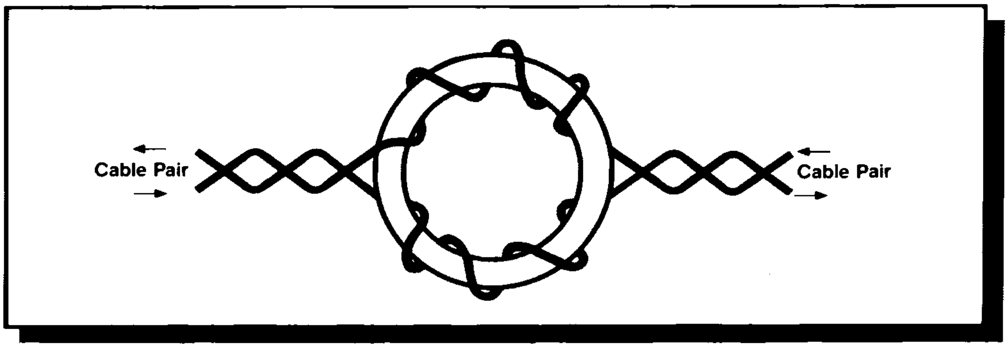
Illustration: Loaded/Non Loaded Frequency Response



Explanation: Load Coils

As you can see in this FR graph, higher frequencies show great attenuation when the cable is not loaded. With loading, the FR curve flattens out and attenuation is reduced over the voice frequency band. When you get to higher frequencies, over 3500Hz, even loaded cable shows marked attenuation.

Illustration: Load Coil



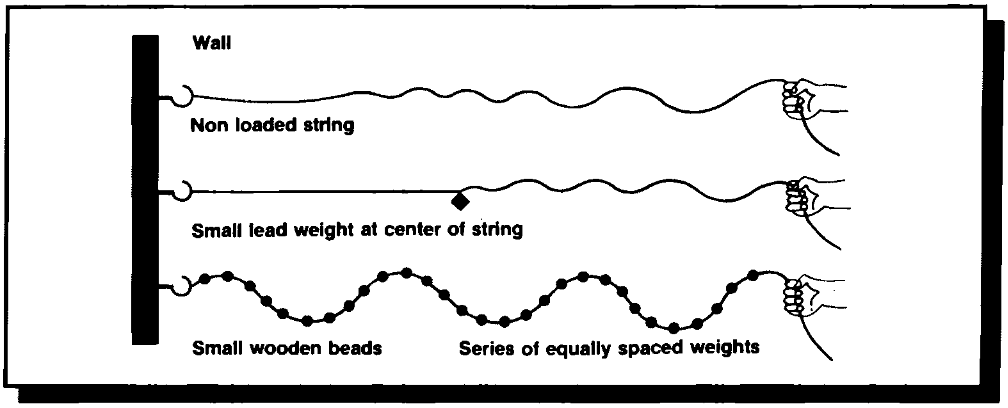
Explanation: What's a Load Coil?

A loading coil is nothing but a doughnut-shaped core wound with copper wire. But, for the record, the load coils are used to increase the distributed inductance of the cable pair.

Comment

The critical aspect of loaded cable is the spacing of the load coils. The distance between the coils will be determined largely by the cable gauge you're using and the type of transmission facility that you're dealing with.

Illustration: Why it Works



Explanation

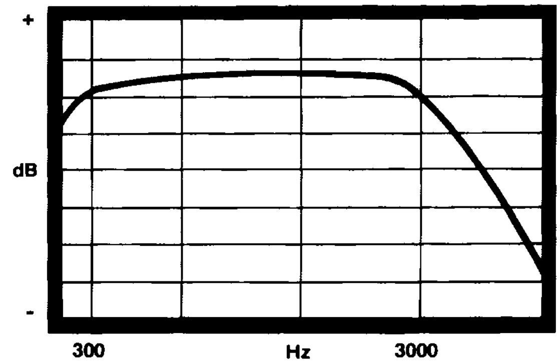
This diagram shows, in principle, how loaded cable works. The AC current waves keep their form longer when the load coils (weights) are evenly distributed.

Note

As a rule of thumb, every facility using over 18 kilofeet of cable will be loaded.

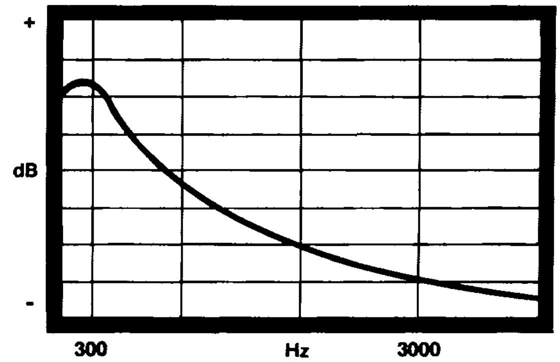
Exercise 1

1. For 18k′ 22 gauge telephone cable:



The above graph shows the FR of ____________________ cable.

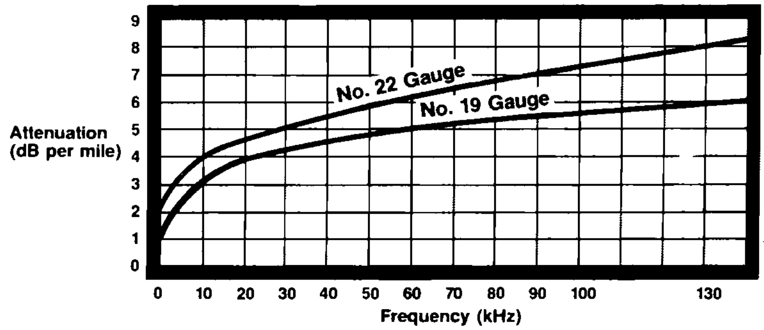
2.



The above Frequency Response graph indicates the use of ______________ cable.

Illustration: Attenuation/Gauges

Conductor Size (gauge)	DC Resistance (ohms per loop mile)	AC 1000-Hertz Attenuation (dB per mile)	Capacitance (µf per mile)
16	42	0.73	0.060
19	86	1.26	0.084
22	172	1.79	0.082
24	274	2.31	0.084
26	440	2.86	0.079



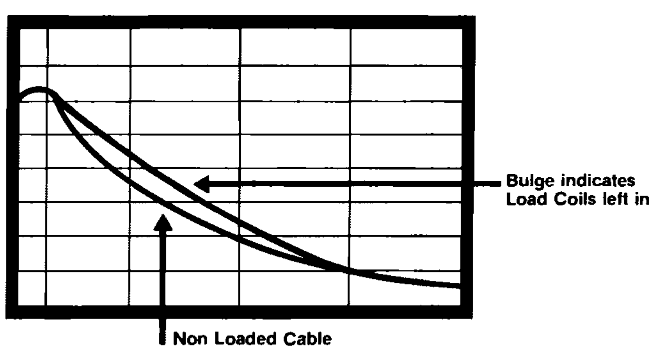
Explanation: Loss Over Distance

This diagram is concerned with two types of loss: DC resistance as measured in ohms/loop mile, and AC attenuation as measured in dB/mile. Both types of loss are closely related to distance, and they both vary with the conductor size that you're using. To reiterate a point we made earlier, you'll be considering telephony distances in ohms (Ω). Hence conductor gauge will no longer be a relative factor in judging distance.

Comment

You probably won't be involved in loading cables yourself. And so, you won't have to know how far apart the coils should be spaced. But you probably *will* run into situations where you'll be working with a non-loaded facility which still has a load coil installed.

Illustration: Inadvertent Loading



Explanation: What to Do About Coils

The FR graph above shows an irregularity in the Frequency Response curve. In all likelihood, this means that there's a coil remaining somewhere on this non-loaded facility. This is especially important if you're working on a circuit for radio transmission. To get broadcast quality frequency response, it's essential that there be no load coils present. When you run into a case where one's still in place, it's best to call Outside Plant and have them remove the unneeded coil.

The above illustration is merely an example. But now, you can diagnose the problem yourself if you run into this kind of FR graph.

Explanation: Loaded Cable Problems

There's a practical limit to the use of loaded cable. Each coil increases series resistance and it reduces the travel speed of the transmission currents. It also changes the impedance of the facility.

Definition: Impedance

Impedance is officially defined as the sum of circuit resistance plus reactance. But you'll probably find it easier to think of impedance as AC resistance.

Importance of Impedance

Impedance is one of the most important cable characteristics, and it is largely determined by the type of facility being used.

Facility	*Normal Impedance (Z)*
Non loaded cable	600 Ω @ 1000Hz
Carrier facility	600 Ω @ 1000Hz
Loaded cable	1200 Ω @ 1000Hz

Comment

It's critical to remember these impedances. Because almost every piece of telephone equipment must ultimately be optioned to interface with a facility of specific impedance.

Explanation

Impedance matching is one constant concern of any telephony professional. You'll be using this principle on almost every installation assignment.

Application: Impedance Matching

Some other impedances are used in special situations. You can use a compromise impedance of 900Ω when you're interfacing with a switched network and you don't know what the facility is on the other side of the switch.

Application	*Alternative Impedance*
Cables which connect subscriber lines (non loaded) to C.O. trunk lines (loaded)	900 Ω @ 1000Hz
Intentional mismatch to provide more equal attenuation across voice band (non loaded)	150 Ω @ 1000Hz

Comment: Equalization

We'll be talking more about equalization in Chapter 5.

Exercise 2

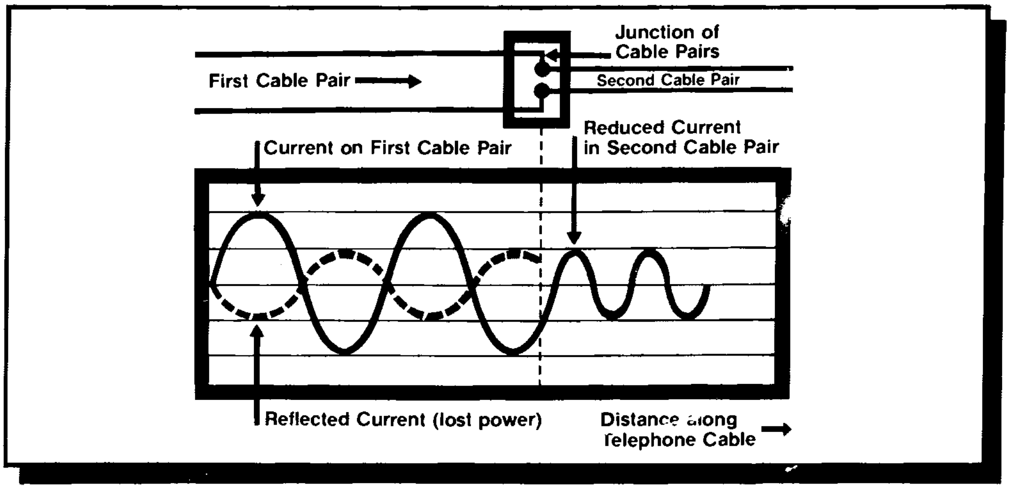
In the space at left, match the correct impedance with the circuit applications described below:

_____ 1. Intentional impedance mismatch used as limited equalization for non loaded cable	A. 150 Ohms
	B. 600 Ohms
_____ 2. Impedance of loaded cable	C. 750 Ohms
_____ 3. Impedance of non loaded cable and carrier	D. 900 Ohms
_____ 4. Compromise impedance, commonly used when interfacing a switch between loaded and non loaded cable	E. 1200 Ohms

Avoiding Echo

The importance of impedance matching becomes critical when we start to look at the problem of *echo* which is measured by Return Loss.

Illustration: Impedance Mismatch



Explanation: Echo

As you can see from the above diagram, when facilities are mismatched, some energy is reflected back along the original transmission path. This reflection not only causes an echo in the circuit, it also means that not all of the transmit power travels across the interface. Any echo energy is lost as far as transmission goes.

Comment

Obviously, the echo and its resultant energy loss are unacceptable telephone performance problems. They can both be solved by merely adjusting the impedance matching capability of the interfacing device. Impedance matching is a very common problem. It's one that can be solved quite easily with most manufacturer's equipment. But it's a consideration that we'll be mentioning throughout this training series and one that you'll face regularly in the field.

Explanation: Return Loss

Return Loss is a measurement in dBs of the difference between Transmit (XMT) power applied and any reflected power (echo). The greater the difference between XMT power and echo, the better the circuit. So, you want to achieve the *highest* possible Return Loss when you set up your circuit. The minimum acceptable standard is 20dB Return Loss.

Exercise 3

Place an "X" beside the correct statements:

1. Two Wire Return Loss can be described as:

_____ A. The intrusion of unrelated circuits on a dedicated line.

_____ B. The loss of power over distance.

_____ C. Inadequate frequency response.

_____ D. The measurement of reflected power between mismatched facility interfaces.

2. Low two Wire Return Loss is indicated by:

_____ A. Crosstalk

_____ B. Echo

_____ C. Noticeable delay between Transmit and Receive functions.

_____ D. Inadequate sidetone levels.

3. Place an "X" beside the optimum Return Loss amount listed below:

_____ A. 16dB

_____ B. 7dBm

_____ C. 0dB

_____ D. 13dBm

_____ E. 24V

_____ F. 24dB

Extended Signaling Range

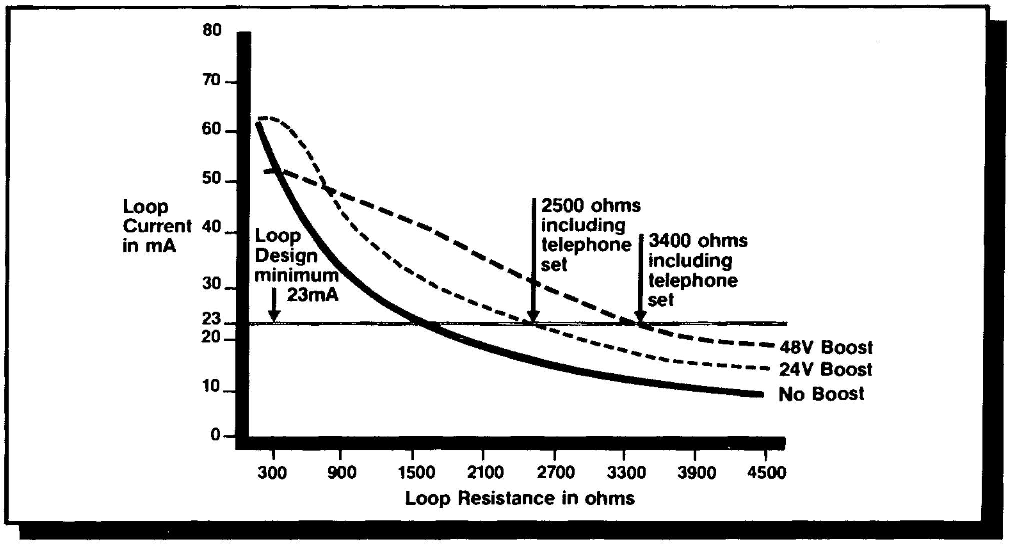
In our discussion of loaded cable and impedance matching, we talked about transmission problems and some of the ways we could enhance transmission performance over extended 2 Wire circuits.

However, just as transmission quality deteriorates over distance, DC signaling information also suffers some power loss.

Loop Extender Location

A Loop Extender may be installed at the C.O. to extend the signaling range of the Central Office. The Loop Extender module inserts floating power sources whenever loop current is drawn on that particular circuit. By floating power source, we mean that the Loop Extender may be placed in different configurations within the circuit. Its position is not fixed as you'll see on the next page.

Illustration: Loop Extension



Application: Loop Extenders

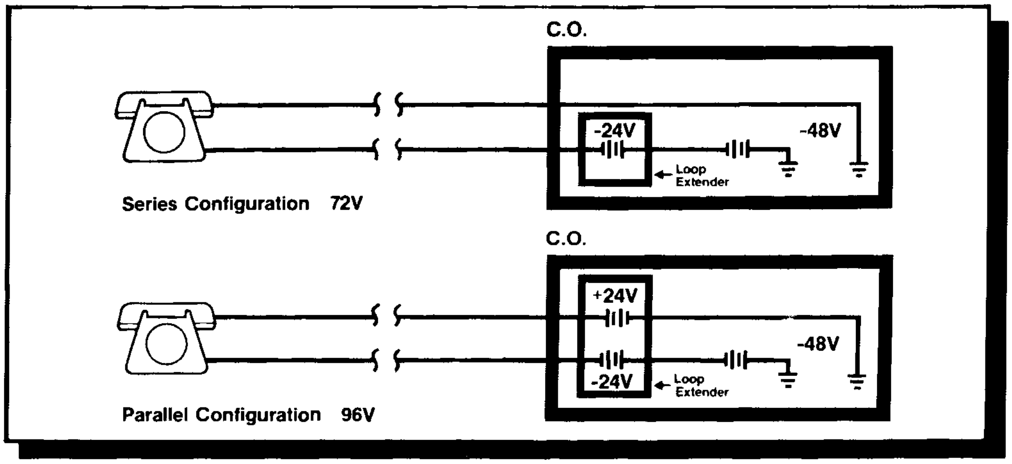
The Loop Extender can just about double the signaling range of the C.O. However, it must be located as close to the C.O. switching gear as possible. In fact, for every ohm of resistance between the Loop Extender and the C.O. switch, there's a 2Ω drop in loop circuit range.

Consequently, only one Loop Extender can be used on any given circuit. Thus, the Loop Extender's proximity to the C.O. is the major limitation to its effectiveness.

Comment

In order to improve signaling performance any further, it's necessary to install a boost device away from the C.O., somewhere along the circuit itself.

Illustration: Parallel or Series Configuration



Explanation: Configuration

As a floating power source, a Loop Extender may be placed on one side of a circuit — as an extra battery connected to Tip or Ring — or in a parallel configuration to boost the entire circuit.

Application

The Loop Extender does not supply power constantly. It detects small amounts of loop current flow, then switches in extra power. It improves Ring Trip and can add voltage, effectively making a 48V Central Office into a 96V C.O.

Although a Loop Extender can increase a C.O.'s signaling loop, it does not affect the range of the Ring Generator or enhance any voice tranmission functions of the circuit.

Exercise 4

Describe the purpose of a Loop Extender, its usual location on a phone circuit, and its primary limitation:

1. A Loop Extender is used to ____

   ____.

2. A Loop Extender is usually located ________________________________.

3. The primary limitation of a Loop Extender is ____________________________

   ____.

Section 4: Repeaters and DLLs

Instructional Objectives

By the end of this text section you'll be able to:

1. Locate the placement of a Dial Long Line within a 2000Ω circuit and specify two alternative arrangements for a 5000Ω circuit.
2. Specify which Dial Long Line functions are normally provided by a Central Office and which are usually provided by a telephone.
3. Label the components of a typical PBX circuit and sequence the events which occur for both incoming and outgoing calls on circuits using Ground Start supervision.
4. Locate and option a Dial Long Line for a specified OPS circuit application.
5. Correlate specific Repeater characteristic to Hybrid, Switched-Gain and Negative Impedance types of repeaters.

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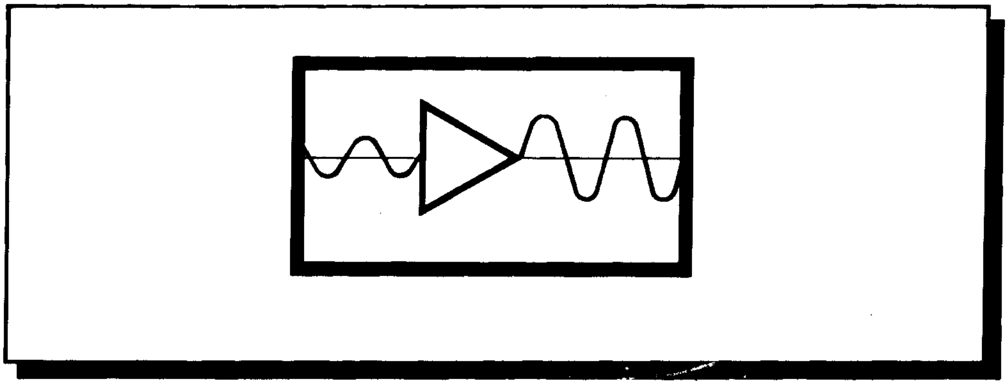
Transmission Review

In the last section we discussed attenuation, loss over distance. Load coils were used initially to improve transmission frequency response. But eventually, you've got to add some device along the circuit which will add gain to the signal. The gain or amplifier device is a Voice Frequency Repeater.

Illustration: Repeater



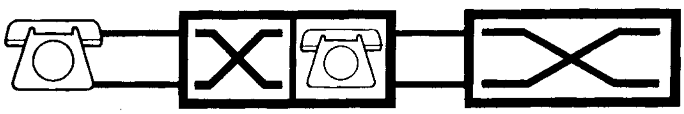
Explanation: 2 Wire Repeater

The Repeater is essentially a VF Amplifier. It amplifies the transmission level. An Amplifier or Repeater is symbolized by a triangle. And the apex of the triangle points in the direction of the output. We'll talk about Repeaters more extensively later on in this section.

Signaling Review

In the last text section, we also saw how signaling range is affected by the length of the loop circuit. A Loop Extender can be installed at the C.O. to increase signaling range. But its effectiveness is limited since only one Loop Extender can be used per circuit. To extend signaling distance even further, you've got to install a device at an intermediate point on the circuit. This device is called a Dial Long Line or DLL.

Illustration: Dial Long Line

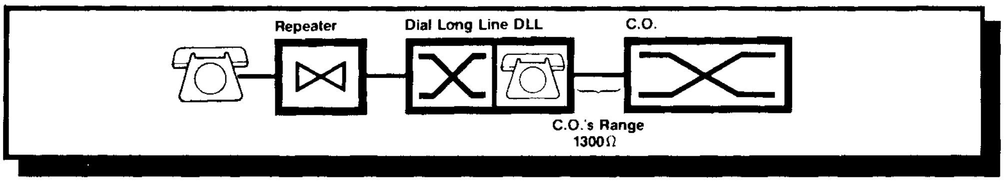


Explanation: DLL

The DLL can increase the signaling range of a circuit without changing the C.O. or station end equipment. In essence, the DLL acts like a telephone to the C.O. side of the circuit, and like a C.O. to the telephone side. And unlike a Loop Extender, it can be installed in series, at various points along the facility, whenever a signaling boost is required. When you use a Dial Long Line, you're starting to operate in the area of Special Services.

The DLL is used to improve on-hook/off-hook detection (Loop Sense). Because that's usually the first C.O. function to have problems. The Ring Generator will still be able to ring the phone long after Loop Sense performance has deteriorated.

Illustration: DLL Circuit



Explanation

A Dial Long Line can be placed anywhere along a loop circuit. But it's usually best located near the far end of the C.O.'s normal signaling range. It's commonly installed alongside a 2 Wire Repeater to offer both extended transmission and signaling capabilities.

Application: DLL Placement

DLL placement usually depends on the signaling or loop range of the Central Office. This range includes the resistance of the telephone instrument and the resistance inherent in the DLL unit itself.

C.O. Range – DLL Resistance = furthest placement from C.O.

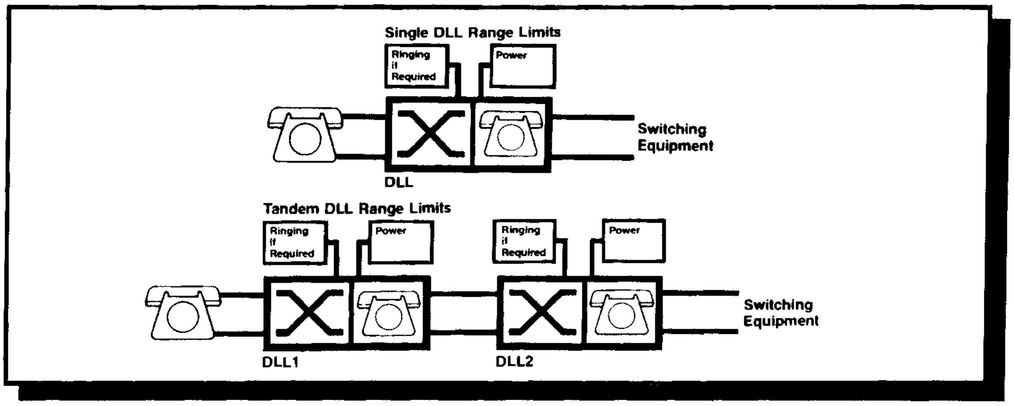
You also need to think about the signaling range of the DLL itself in order to decide whether to use more than one in series. The signaling range of the DLL varies according to battery voltage.

DLL Voltage Options

48V DC = 3000 Ohms on station side — with the same 48V DC source that powers the module

72V DC = 4500 Ohms on station side via external power source
96V DC = 6000 Ohms on station side via external power source

Illustration: Tandem DLLs



Explanation: DLL Alternatives

As you can see, there's more than one way to set up a DLL in a circuit. In the first example, the DLL is placed at the far end of the normal range of the switching equipment. Luckily, the single DLL provides enough signaling boost to supply the current requirements of the station.

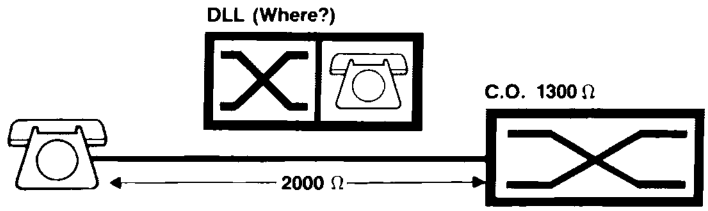
In the second example, DLL2 cannot provide sufficient current for the station. As a result, DLL1 is added for the extra range.

A third alternative (not shown) is to increase the DLL's power voltage with an external battery source, thereby extending its signaling range to reach the distant station.

These alternatives are not always set out in your CLR (Circuit Layout Record). So it's important to realize your choices so you can make the best decision while you're on the job.

Exercise 1

1.



In the above 2000Ω circuit, the C.O. has a standard signaling range of 1300Ω. The DLL has an internal resistance of 200Ω. Place an "X" beside the optimum location of the Dial Long Line (furthest position from C.O.).

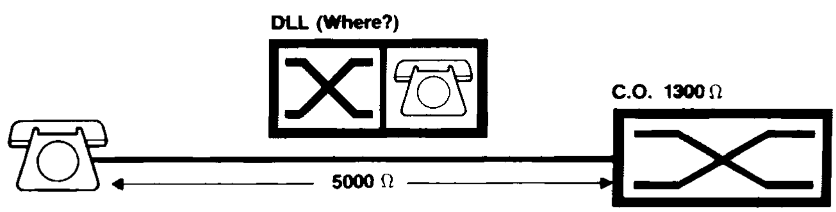
_____ A. 2000Ω from C.O.

_____ B. As far as 1200Ω from C.O.

_____ C. As far as 1000Ω from C.O.

_____ D. None of the above. It should be _______________.

2.

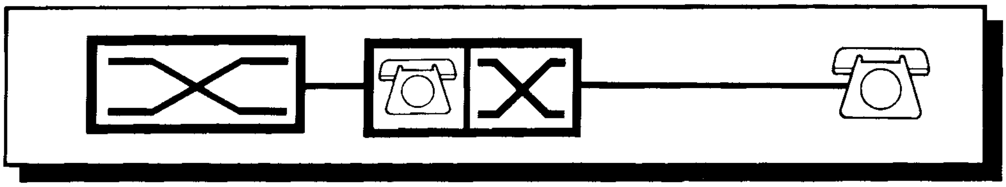


This is the same 1300Ω C.O., but now the loop circuit length is 5000Ω. A DLL still has 200Ω internal resistance. What two choices do you have to handle this circuit?

A. _______________

B. _______________

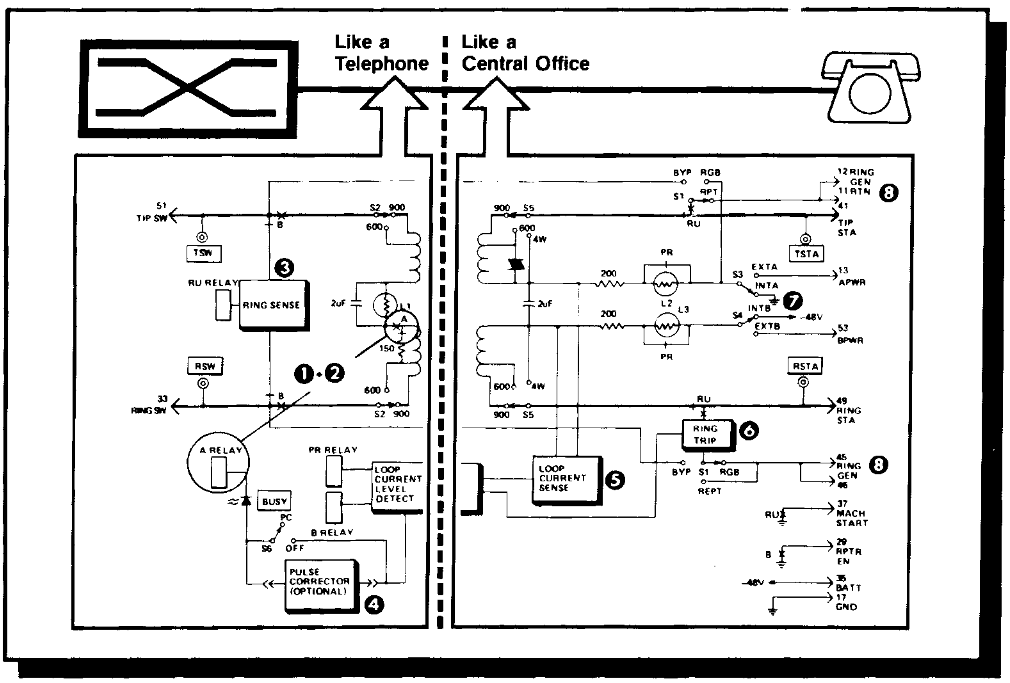
Illustration:
A DLL Circuit



Comment

In our simplified diagram, we've shown that a DLL looks like a telephone to the C.O. And it looks like a C.O. to the telephone.

Illustration:
The Block Diagram



Explanation:
Functional Breakdown

In reality, this is what the internal DLL circuitry looks like. The listed components provide the following functions:

Telset Functions

1. Regenerates off-hook.
2. Repeats dial pulsing — The A relay shown operates the A contact. This is the equivalent of the phone's hook switch and dial pulse contact.
3. Detects Ring Gen from C.O. — The Ring Sense circuitry is connected directly to Tip and Ring just like the ringer on the telephone.
4. Optional pulse correction (required if more than two DLLs are used in tandem)

C.O. Functions

5. Loop Sense — this eventually controls the A relay.
6. Ring Trip — this is the DC detector which idles the ring-up (RU) relay to stop the phone from ringing.
7. Talk Battery (internal or external)
8. Ring Generator connection

Exercise 2

1. Of the DLL functions listed below, place a "T" beside those which are ordinarily considered telephone functions, and place a "C" beside those which are Central Office functions.

_____ Duplicates loop closure (off-hook)

_____ Repeats dial pulsing

_____ Applies Ring Generator

_____ Provides Ring Trip

_____ Detects ringing

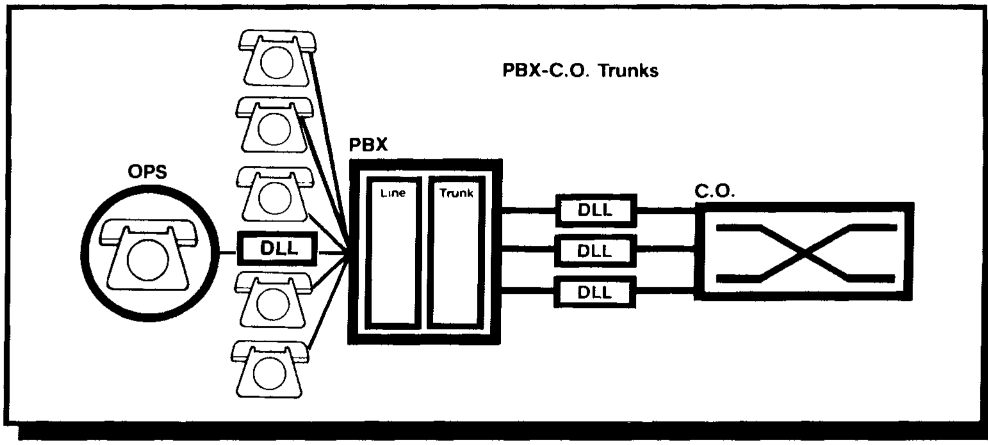
_____ Supplies Talk Battery

_____ Corrects dial pulses

_____ Provides Loop Sense

_____ Regenerates off-hook

Illustration: DLLs/PBX/Trunks



Explanation

Dial Long Lines are often used in PBX circuits to extend the signaling range between the PBX (Private Branch Exchange) and the C.O. And between the PBX and its extensions.

Definition: PBX

A PBX can be thought of as a private C.O. It receives calls from a Central Office over a PBX trunk and switches them to the numerous extension telephones connected to it. The PBX provides Battery, Ring Gen, Ring Trip and switching for all its extensions. But it does have a shorter signaling range than a regular C.O. — typically only about 800Ω.

Comment

Sometimes, in order to reach an OPS (Off-Premise Station), or other distant PBX station, the PBX needs some extra signaling power along the circuit. This can be provided with the Dial Long Line.

Application: Trunk Line

A DLL can also be used on the trunk or C.O. side of the PBX. Individual Dial Long Line modules can provide extended signaling range for the various 2 or 4 Wire trunk lines which tie into the PBX from the C.O. But because they're shared facilities, trunks do provide some special problems.

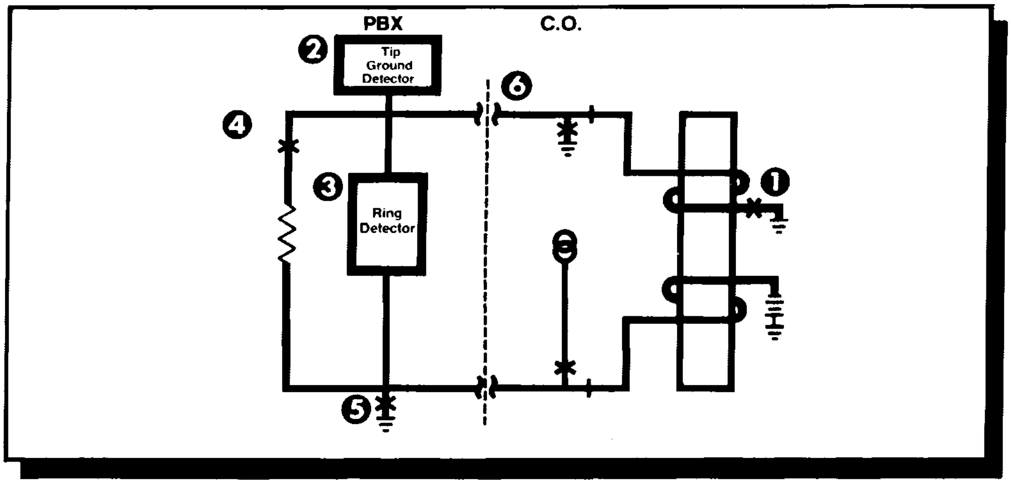
Explanation: Loop Start

All the loop circuits we've discussed so far have been *loop start* circuits. With loop start supervision, current flows when the phone goes off-hook, causing the line to go busy. In a PBX application, the line side stations are usually loop start circuits.

Ground Start Rationale

Ground Start PBXs were created specifically to prevent head-on or glare — the superimposition of one call over another, which is made possible by the shared status of a trunk. During the ring cycle's 4 second silent period, it's possible for an incoming call to be mistakenly switched to an off-hook extension that is requesting service. That's a head-on collision. Basically, Ground Start supervision was created to seize the PBX trunk as soon as that line is accessed by any station. That way no incoming call can be mistakenly switched to the wrong extension.

Illustration: Ground Start PBX



Explanation: Ground Start PBX

When an incoming call is sent from the local C.O. to the PBX, the Central Office applies a ground to Tip (1). The PBX reads this at the Tip Ground Detector (2), and seizes that line. From this point, there is no possibility of outgoing access of that trunk. Hence no glare. Next, the console notes ringing (3) and the operator switches the call out for loop closure (4). Finally, the extension rings.

As for the outgoing sequence, in the idle state, no ground is applied on Tip at the C.O.; it's open. As soon as a call is initiated, the PBX seizes the trunk by grounding Ring (5). This causes loop current to flow from the battery to grounded Ring.

With loop current flowing, the line relay sends dial tone and Tip Ground toward the PBX (6). The PBX's Tip Ground Detector senses ground (2) and causes loop closure plus the removal of Ring Ground (4 & 5). This enables the Central Office to receive dial pulsing information.

Exercise 3

1. In the space below, place the appropriate diagram numbers shown beside the corresponding components listed.

_____ PBX

_____ PBX trunk circuit

_____ PBX line circuit

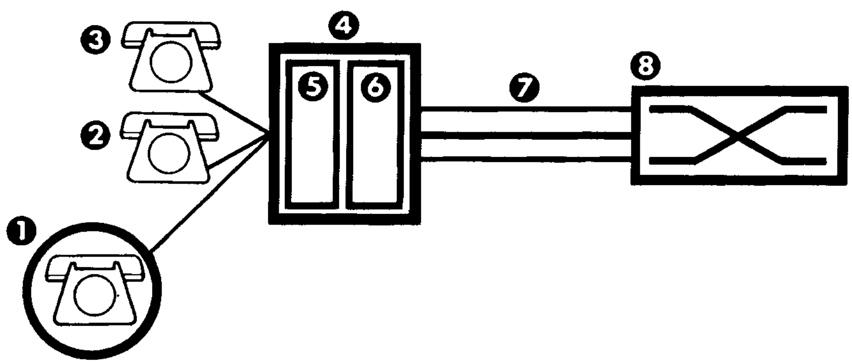
_____ Central Office

_____ Telephones (stations)

_____ OPS

_____ PBX trunk or tie lines

2.



Number the following events in their proper sequence for Ground Start PBX.

Incoming

_____ Operator notes ringing — switches out call

_____ PBX reads Tip Ground — seizes the line

_____ Station rings

_____ C.O. grounds Tip

Outgoing

_____ Line relay sends dial tone and Tip Ground to PBX

_____ PBX places Ground on Ring

_____ Station accesses trunk

_____ Tip Ground detector causes loop closure and removal of Ring Ground

_____ C.O. can receive dial pulses

Explanation: DLL Ring Gen

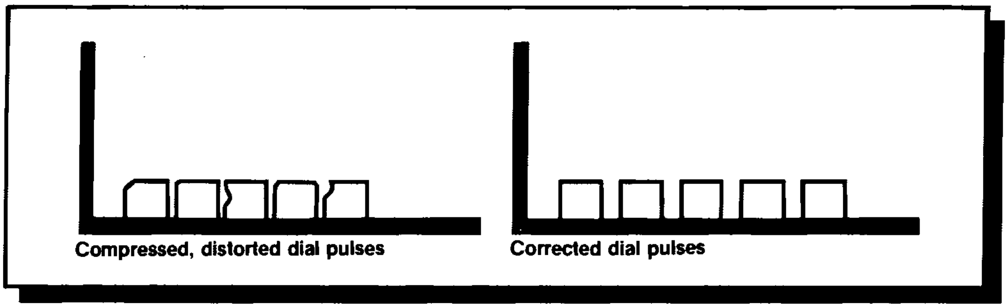
With a DLL, you can use different ways of connecting Ring Generator. Essentially, you have three Ring Gen choices when you install the module.

BYPASS — No Ring Gen is added. The C.O.'s Ring Gen is passed directly through the module. This is used because normally signaling/supervision range is much shorter than Ring Gen range.

BIAS — Negatively biased Ring Gen is added at the DLL. This is always the case with Ground Start trunk circuits.

REPEAT — Ring Gen is repeated at the DLL. This can be wired for either positive or negative biasing, depending on the C.O.

Illustration: Pulse Correction



Explanation

The DLL pulse corrector is a separate subassembly or baby-board that plugs into the DLL module. Before inserting the corrector, you must set the option switch to activate its use.

On the other hand, if you're not using the pulse corrector, you've got to be sure that the PC switch is set for NO pulse correction.

Comment

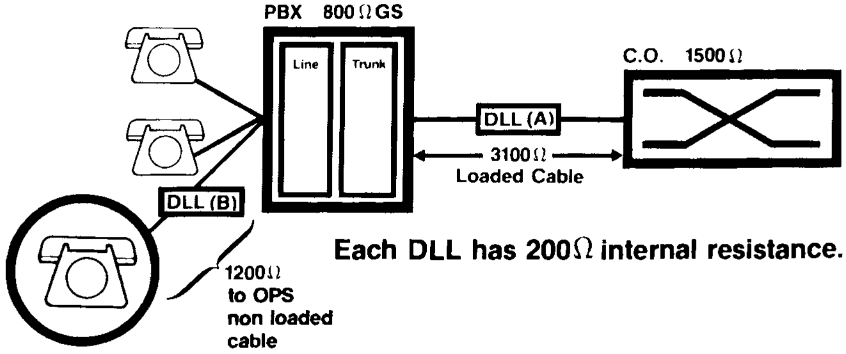
You may need to add pulse correction when you're signaling over a very long loop because dial pulses can become distorted over distance. The leading edges can become sheared due to capacitance, or the pulses themselves can run together so as to be indistinguishable. So, the DLL's optional pulse corrector should be used whenever more than two DLLs are used in tandem. Or, whenever you can't get the party you're dialing.

Explanation

Below, we've listed some common DLL installation problems, their probable causes and their likely solutions.

Problem	*Probable Causes*	*Likely Solutions*
1. Inoperative circuit — no dial tone at station	A. Station and office sides reversed	A. Switch leads — rewire
2. Station rings but can't dial	A. PC switch is in wrong position (no pulse corrector is used)	A. PC switch to NO
	B. Too much resistance in circuit	B. Check CLR — move unit or increase power
3. No Ring Trip	A. Unbiased Ring Generator	A. Check biasing — Rewire or re-bias as needed
4. Dialing wrong number	A. Pulse distortion	A. Add pulse corrector
	B. Switching problem at C.O.	B. Check switching system

Exercise 4



1. Where should DLL A go in above circuit? ______________________

2. Where should DLL B probably go in above circuit? ______________________

3. Place an "X" in the spaces provided to indicate correct option switch settings for the OPS side DLL.

Switch		*Then*
_____ S1	Bypass — use PBX's Ring Gen	BYP
_____ S1	Negative bias	RGB
_____ S1	Repeat existing bias	RPT
_____ S2	Switch side impedance 600Ω	600
_____ S2	Switch side impedance 900Ω	900
_____ S3, 4	Internal loop power	INTA, INTB
_____ S3, 4	External loop power	EXTA, EXTB
_____ S5	Station side impedance 600Ω	600
_____ S5	Station side impedance 900Ω	900
_____ S6	Pulse correction	PC
_____ S6	No pulse correction	OFF

4. But after doing all this and installing the module, you find that you have an inoperative circuit — that the telephone doesn't draw dial tone —

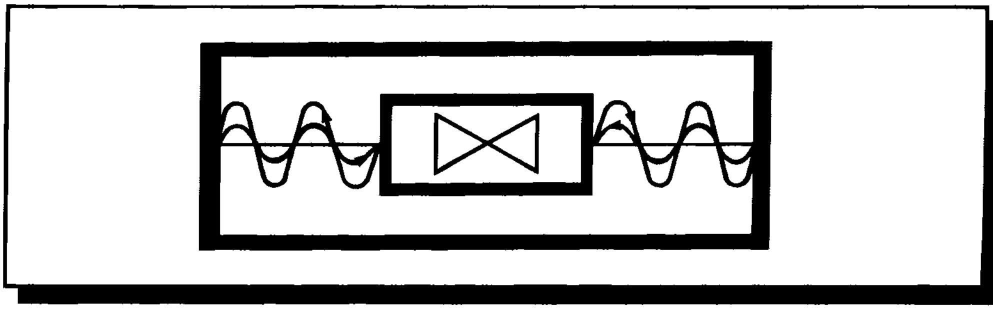
   you've probably ______________________________________

   and have to ______________________________________
   to solve it.

Review

Now that we've extended our signaling loop with a DLL, it's time we also think about improving transmission performance over the circuit. On a 2 Wire circuit, the conditioning of transmission is accomplished with a 2 Wire Repeater.

Illustration: 2 Wire Repeater



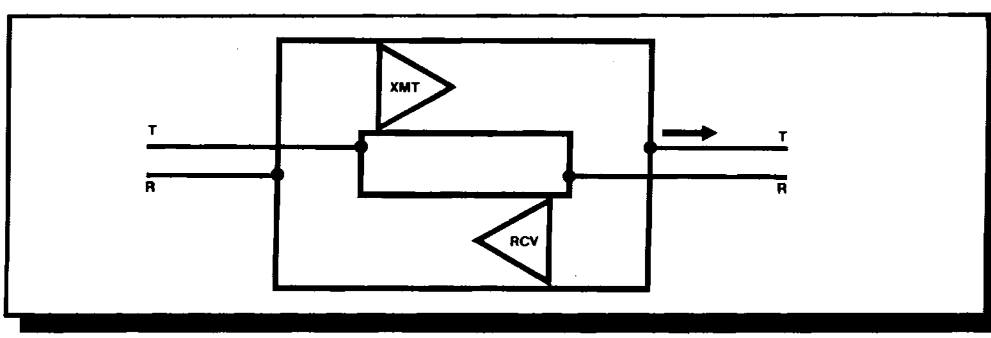
Explanation

A 2 Wire Repeater is a combination of two separate amplifiers, one amplifying the Transmit path, the other amplifying the Receive path of the circuit. A 2 Wire Repeater is symbolized by the bow tie symbol.

Explanation

Actually there are several types of 2 Wire Repeaters on the market, and all of them are a response to a basic engineering problem. To amplify a 2 Wire circuit, you've got to somehow handle the problem of bi-directional transmission, to provide gain in both directions simultaneously.

Illustration: Unstable Circuit



Explanation

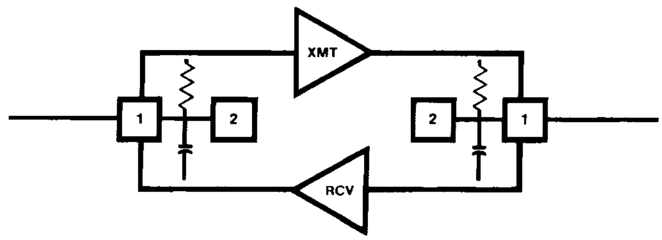
This set up would certainly provide amplification in both directions. But it would also provide a highly unstable circuit. One in which amplified XMT information could cross over to the RCV side amplifier, and vice versa. Voice information could go around in circles indefinitely — the feedback would be amazing. This type of device would sing, howl, and otherwise prove totally unsatisfactory.

Application: Hybrid Switched-Gain Negative-Z Repeaters

So, to solve the problem of instability, telephone engineers have developed various solutions to the problem of amplifying a circuit that carries bi-directional transmission. In telephony, we use:

- Hybrid Repeaters
- Switched-Gain Repeaters
- Negative Impedance Repeaters

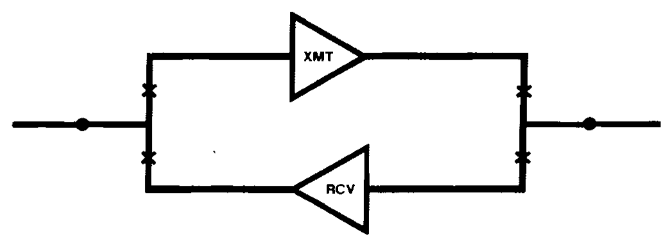
Illustration:
Hybrid Repeater



Explanation

The Hybrid Repeater uses magnetic hybrids (1) with balance networks (2) to separate Transmit and Receive information. Each path is amplified independently, then recombined for transmission along Tip and Ring. The critical engineering problem here is to match 2 Wire impedance with the balance networks to prevent leakage of XMT path energy across the Hybrid to the RCV side of the Repeater.

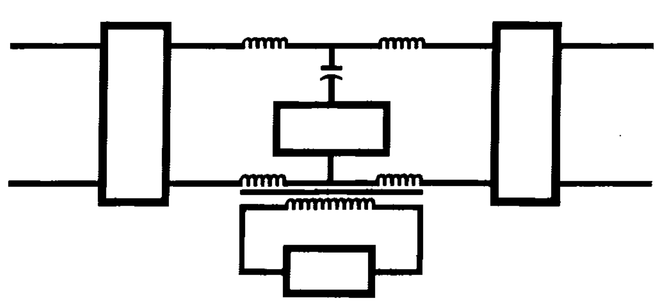
Illustration:
Switched-Gain Repeater



Explanation

The Switched-Gain Repeater boosts transmission level in one direction, while providing an equal amount of loss in the other direction. It's used frequently in circuits where you don't know the exact impedance of the interfacing facility.

Illustration:
Negative-Z Repeater



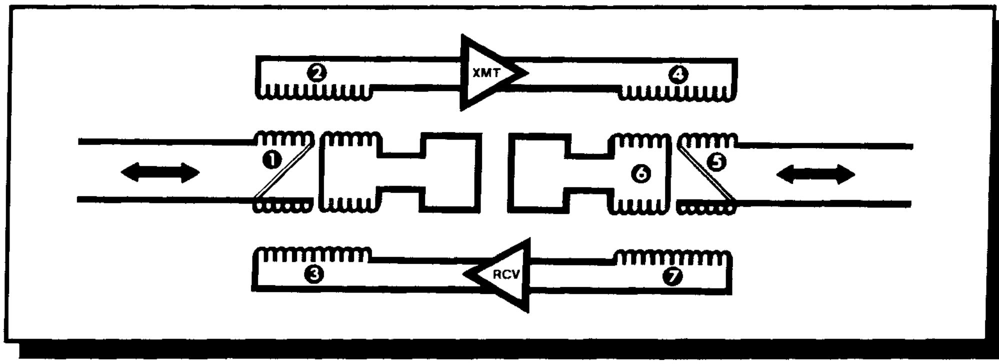
Explanation

A third type of 2 Wire Repeater — the Negative Impedance Repeater — electronically cancels out AC resistance in the circuit. It is an electronically complex device and is not used as commonly as the two other kinds of Repeaters which we'll discuss in more detail.

Hybrid Review

As we said, the Hybrid Repeater uses magnetic hybrids — transformers really — and associated balance networks to separate and later recombine the Transmit and Receive paths. With the Hybrid Repeater, each path is conditioned independently.

Illustration: Hybrid Repeater



Hybrid Induction

Here you can see the sets of coil windings in a 2 Wire Hybrid Repeater. These hybrid coils allow AC current to be induced via magnetic field from one winding into another where it is eventually amplified and recombined with the 2 Wire facility.

The hybrid coils are equal and opposite windings that prevent amplified voice transmission from leaking over from one side of the Repeater to the other.

Procedure: 2 Wire Operation

Going from left to right, unamplified current enters the Repeater and causes a magnetic field to be formed at (1). And this field, in turn, causes a current to be induced on either side of the hybrid. Half of the current goes to the XMT side for amplification (2); the rest goes to the RCV side (3) where it is dissipated as heat. The current passes through the amplifier to another induction coil (4). At this point, the amplified current is split again. Half the current is induced to the 2 Wire Port (5); the other half is induced to the Balance Network (6) where it is dissipated as heat. In effect, currents 5 and 6 cancel each other out at 7. Hence, theoretically at least, no echo.

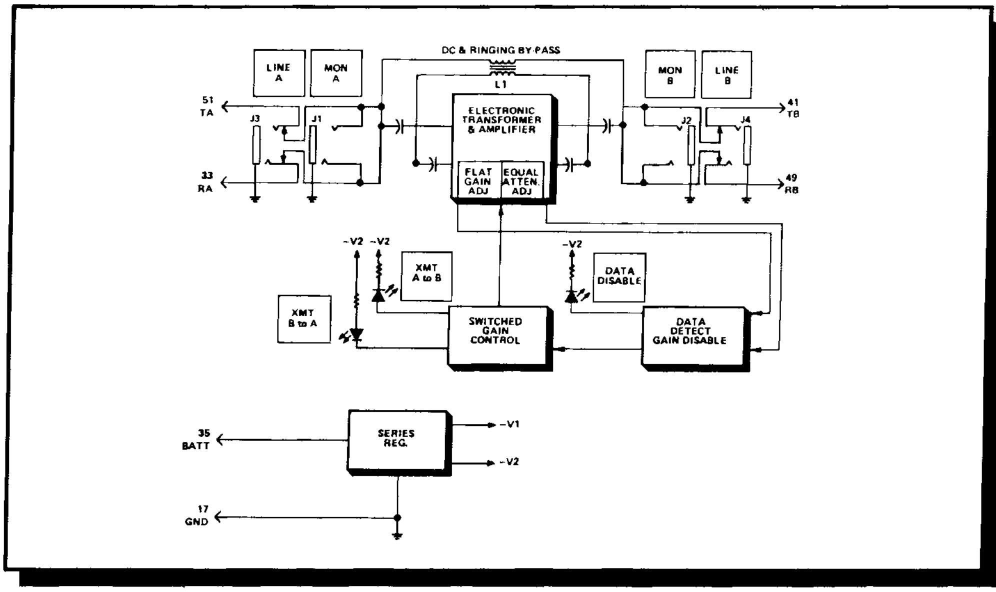
Comment: Balance Network

The impedance of the balance network must be adjusted so that it is exactly equal to impedance of the output facility. This is essential for circuit stability. The balance network's windings must be equal and opposite to 2 Wire Port's in order to cancel out all induced energy and prevent any coupling (that could cause echo or feedback) to the other side of the Repeater.

Note: Inherent Loss

Impedance matching is critical when you're installing any hybrid device. Even when a hybrid is perfectly adjusted, there's an inherent half power, or 3dB loss involved. That's because only half the amplified signal goes out to the facility. The rest is necessarily absorbed by the balance network. There is also an extra 1dB or so of loss because the transformers are not 100% efficient.

Illustration: Switched-Gain Repeater



Switched-Gain Operation

The Switched-Gain Repeater doesn't use a balance network to separate transmission paths. This Repeater boosts the level in one direction; and to maintain circuit stability, it simultaneously provides an equal amount of loss in the other direction. This arrangement results in unconditional circuit stability and excellent transmission performance.

When to Use Switched-Gain

The Switched-Gain Repeater provides gain to the stronger of the two transmission signals. So, this device works perfectly when only one party speaks at a time. But, when two people speak at once (doubletalk), only the stronger signal is amplified. This can cause some impairment of the weaker signal, especially at high gain levels or in the presence of high background noise.

Switched-Gain Benefits

Because there is no balance network to adjust, a Switched-Gain Repeater is very easy to install. In fact, you don't have to bother with impedance matching at all. Just set a single switch for loaded or non loaded cable.

Summary

Switched-Gain Repeaters are very easy to install and they work in situations when you're interfacing facilities of unknown impedances. However, the amplifiers must be disabled for data circuits, because loss is added to one direction of transmission. Also, these Repeaters do show some doubletalk impairment at gain levels of about 10dB. When two people are talking, the louder voice wins.

Note

All Repeaters provide transmission amplification. That is, they increase the levels of AC current. Every amplifier we'll be discussing provides some DC isolation to prevent signaling current from passing through the device. Occasionally, you may find a combined module containing both a Repeater and a Dial Long Line on one board. But electrically, the two functions — transmission and signaling — are handled separately. This is a critical concept and one that you should remember whenever you're setting up any of these modules.

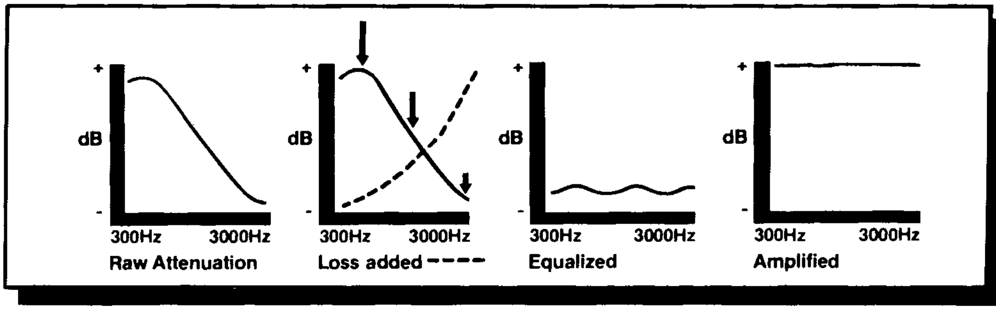
Amplification Review

We've said that a Repeater's primary purpose is to provide gain for transmission by means of an internal amplifier. Transmission levels can be changed by adjusting a potentiometer or by setting DIP switches on the Repeater module. However, a Repeater can also provide equalization to compensate for the pronounced loss of higher frequencies which occurs over distance.

Why we Equalize/Condition

Facilities must be equalized for different qualities of service. Two Wire POTS service is least demanding, while more complex interactive data circuitry or a broadcast radio hook-up requires more stringent standards for exacting frequency response. The reason for this is obvious. While most individuals will tolerate an occasional echo, case of crosstalk, or VF distortion on their home phones, a highly sensitive broadcast radio circuit cannot handle these impairments and still operate accurately and efficiently. Hence, we have to condition phone lines to different specifications depending on their application.

Illustration: Equalization



Explanation

The lefthand FR curve shows an unequalized signal. Although low frequencies show reasonably high levels, the higher frequencies (around 3000Hz) show a marked drop off. This first curve requires equalization.

Procedure: Equalization

To equalize, we make a series of adjustments — either by DIP switches or potentiometer — adding some attenuation or some gain, in order to flatten out the FR curve. Ultimately, we'll be able to add something like the dotted curve shown in the second graph. By doing this, we will essentially eliminate the loss differences across the entire voice bandwidth.

Once we've equalized the signal — achieving essentially the same levels at 300, 1000, and 3000Hz — we can add gain through the Repeater's amplifier. This will amplify transmission equally across the voice bandwidth.

Exercise 5

In the space to the left of the following Repeater characteristics, place an "H" for those characteristics associated with Hybrid Repeaters, and "S" beside those characteristics associated with Switch-Gain Repeaters, and "Z" for characteristics of the Negative Impedance Repeater. Place an "A" for characteristics associated with all types of Repeaters.

_____ Unstable (sings or howls)

_____ Electronically compensates for AC resistance

_____ Limited gain due to internal loss

_____ Must be aligned to exact impedances

_____ Can be used with unknown facilities

_____ Impaired transmission due to doubletalk

Tellabs

Section 5: Basic 4 Wire Transmission

Instructional Objectives

By the end of this text section you'll be able to:

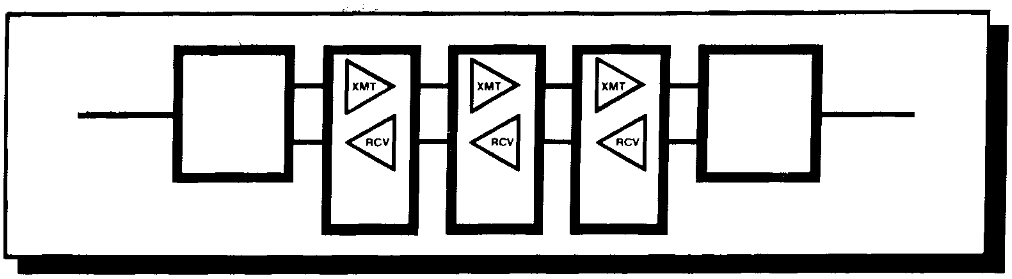
1. Name the four most important benefits of 4 Wire transmission.
2. Identify the two major limitations of the 2 - 4 Wire Magnetic Hybrid Term Set, describe the purpose of the Term Set's Balance Network, and choose the optimal Echo Return Loss (ERL) from a list of five possibilities.
3. List the four conditioning functions provided by a 4 Wire Line Amplifier and match those functions with their proper definitions.
4. State what Simplex (SX) leads do and why they're used with 4 Wire Line Amplifiers.
5. Match the components of a 24V4 circuit application with a list of internal parts.
6. Analyze a sample circuit application to determine attenuation provided by a Term Set, state the amount of gain or loss provided by the 4 Wire Line Amplifier, and specify module impedances and Loop Start or Ground Start supervisory mode for an associated Dial Long Line.
7. *(Optional)* Record the transmission levels and draw the FR curves for a sample amplitude equalization of a circuit using 18kft. of 22 gauge non loaded cable.

Table of Contents

Review:
2 Wire Transmission

In our discussion of 2 Wire circuits, we confronted some of the inherent problems of bi-directional transmission. 2 Wire Repeaters can only provide limited gain for long haul circuits. Transmit and Receive paths must be separated and recombined for amplification to take place.

Illustration:
4 Wire Transmission



Explanation:
4 Wire

The next logical progression to extend transmission capability is to use an adaptation of the 2 Wire Repeater we looked at earlier. We have to make the switch from 2 Wire to 4 Wire transmission.

Comment

With long haul circuits, it becomes much more efficient to operate over 4 Wire facilities than to retain the limited 2 Wire facilities. By keeping the Transmit and Receive paths separate, we can reduce noise, reduce attenuation and allow for more gain to be added over the length of a long distance circuit.

On the other hand, 4 Wire copper facilities obviously cost more than 2 Wire circuits. So, we use 4 Wire circuits only when transmission quality warrants the improvement that can't be achieved with 2 Wire circuits.

2 Wire/4 Wire Benefits

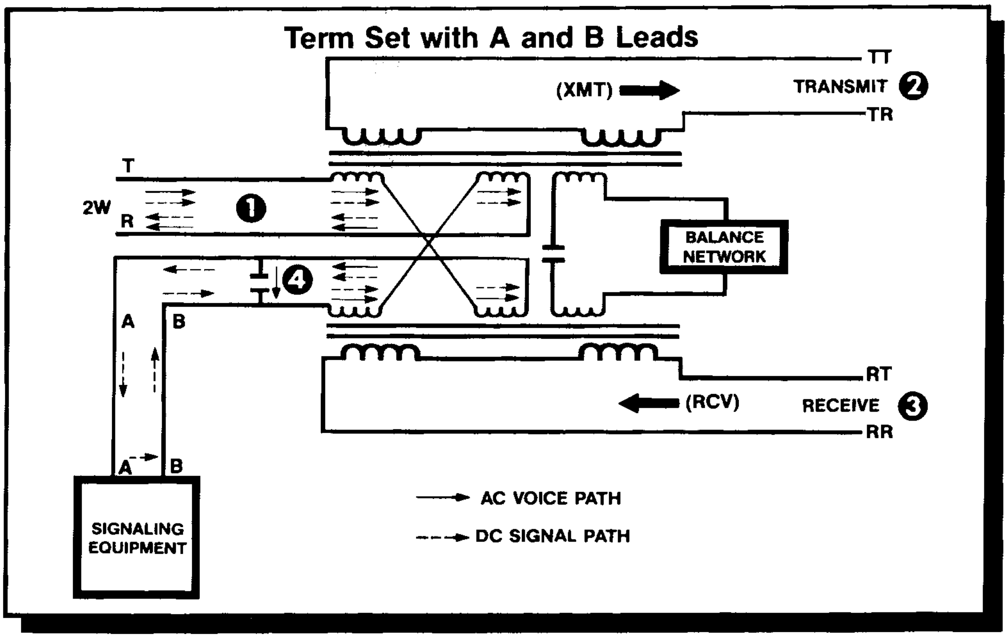
4 Wire Benefits

- Accepts more gain
- Less noise
- Better balance
- More types of signaling
- Best choice for long distances

2 Wire Benefits

- Costs less
- Adequate for local loops and terminations

Illustration:
Terminating Set



Explanation:
Term Set

The 2 Wire to 4 Wire Hybrid or Terminating Set (Term Set) is used to interface 2 Wire and 4 Wire facilities. It's really quite similar to the Hybrid Repeater we discussed in the previous text section. By using a series of impedance matched induction coils and a balance network, the 2 Wire Receive and Transmit paths are split off into separate, uni-directional transmission paths.

Comment

The 2 Wire Tip and Ring (1) are input to the Term Set. On the 4 Wire side, there is a Transmit Tip and Ring pair (2) as well as a Receive Tip and Ring (3). Thus, each path can be conditioned — amplified and equalized — separately as needed.

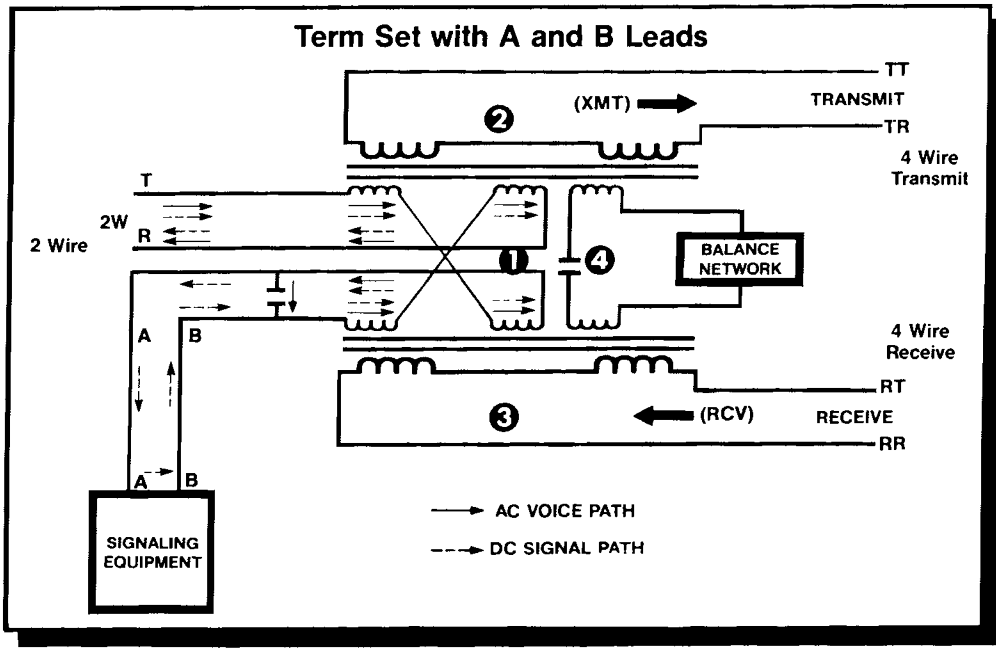
DC Isolation and Signaling

Because of the DC isolation of the induction coils, DC signaling current does not pass through the Term Set's hybrids. A&B signaling leads (4) must be looped around the Term Set and eventually recombined with the XMT and RCV paths. This allows for a very wide variety of signaling treatments to be used. And you'll learn about these in subsequent text sections.

Note:
A&B Leads

In thinking of A&B leads, remember:
- A&B leads always are found on the 2 Wire side of the circuit.
- A lead is associated with Tip.
- B lead is associated with Ring.

Illustration:
Term Set



Hybrid Operation

Let's follow the flow of transmission as it goes in both directions through the Term Set.

First, for the 2 Wire transmission. Energy passes through the coil windings of the 2 Wire Port (1) where half of it is induced into the XMT path (2). The other half is induced to the RCV path, where it is dissipated as heat (3).

The 4 Wire Receive side is a little trickier. Current enters through the RCV Tip & Ring, and passes through that side's induction coil (3). Here, half the energy is induced into the 2 Wire Port (1) and out the 2 Wire Tip & Ring. The other half of the RCV energy is induced into the Balance Network where it is dissipated as heat (4). Again — as in the 2 Wire Repeater — the Bal Net's impedance must perfectly match the impedance of the 2 Wire facility. That way, opposite and equal currents cancel each other out so that no RCV current will accidentally pass across the hybrid up to the XMT side of the Term Set.

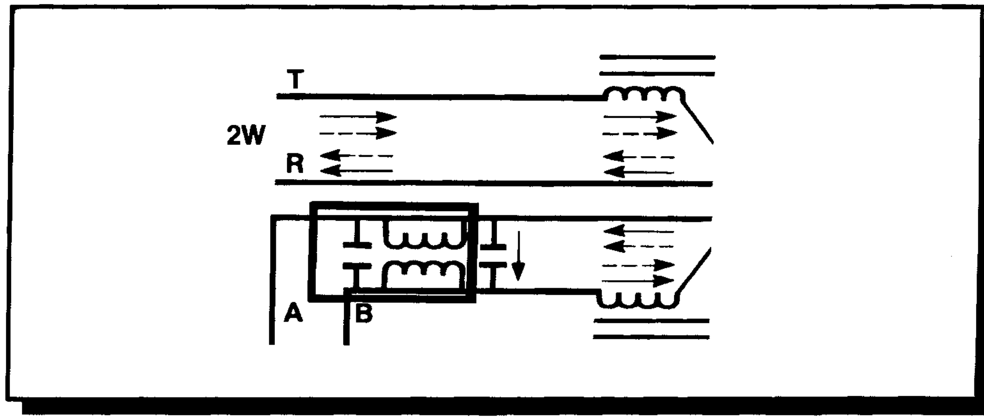
Hybrid Loss

With the Term Set, as in all hybrid devices, you necessarily lose half the signal to the balance network. This accounts for a minimum 3dB loss. In actuality, there's really something like a 4 ± 0.5dB loss due to internal resistance within the module.

Note: Signaling Isolation

Only AC current is induced across a hybrid's coil windings. Hence DC signaling information stays on the 2 Wire side. The Term Set's A&B leads are used to carry signaling current and allow external strengthening of that current — through a Dial Long Line or other device — before it is recombined with the 4 Wire side.

Illustration



Explanation: External Battery and Filter Capacitor

In cases when you need to add external battery across your A&B leads for greater signaling range, you'll want to use a Term Set that provides a special A&B lead inductor and filter capacitor. This will filter out any circuit noise associated with the external battery. On the other hand, use of the filter capacitor can result in either pre-trip or pulse distortion. If you run into either of these problems, just switch off the filter capacitor. You may get some extra circuit noise, but that's preferable to the pre-trip or dialing inaccuracies that you'll face otherwise.

Balance Network and NBOC

The compromise balance network built into the Term Set prevents induction of RCV path energy over to the XMT path. Another method of reducing circuit instability is through Network Build Out Capacitance (NBOC). This compensates for excessive facility capacitance found mostly with non-loaded cable and is normally introduced by a series of DIP switches on the Term Set module. These additive switches must be set to obtain the highest possible Echo Return Loss. To measure this, connect a Return Loss Meter to the circuit, then experiment with combinations of the NBOC switches until you get the highest Echo Return Loss reading on the meter.

Precision Balance Networks

For the most part, the Term Set's internal Compromise Balance Network will adjust impedances accurately. But, there will be occasions, like when you're terminating directly to a telset or a long length of loaded cable, when you'll need to make a more accurate adjustment. In those cases, an optional Precision Balance Network (PBN) provides precise impedance matching to the 2 Wire Port. A separate PBN Practice will tell you exactly how it should be set.

Term Set Level Adjust

Term Sets provide you with padding capability to allow you to achieve the necessary insertion levels for subsequent transmission. Hence, a Term Set is a strictly passive device. It provides no amplification, that function handled by a Line Amplifier.

Exercise 1

In the spaces at left, place an "X" beside the 4 most important benefits of 4 Wire transmission as compared to 2 Wire circuits.

_____ 1. Less noise

_____ 2. Able to handle 4 calls at once

_____ 3. Separate Transmit and Receive paths

_____ 4. Cheaper to install

_____ 5. Will accept more gain

_____ 6. Simplifies signaling

_____ 7. Allows for wide variety of signaling treatments

Exercise 2

1. In the spaces provided, place an "X" beside the two major limitations of a 2 - 4 Wire Magnetic Hybrid Term Set.

   _____ A. Adds too much gain

   _____ B. Requires exact impedance matching

   _____ C. Cannot be used with loaded cable

   _____ D. Loss of 4 ± .5dB

   _____ E. Signaling information cannot pass

2. Place an "X" beside the primary purpose of the Balance Network.

   _____ A. Provide signaling continuity

   _____ B. Balance 4 Wire Ports

   _____ C. Match impedance of 2 Wire Port

3. Place an "X" beside the optimal Echo Return Loss of those listed below:

   _____ A. 20dBm

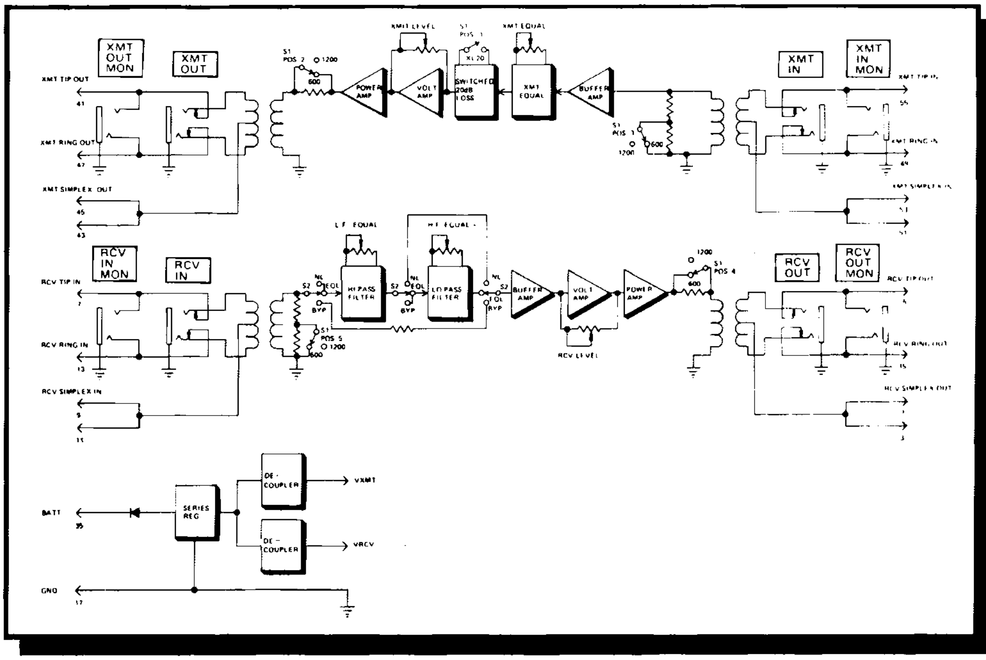
   _____ B. 28dB

   _____ C. 35dBm0

   _____ D. 0dB

   _____ E. 27dB

Illustration: Line Amp



Application: Line Amp

A 4 Wire Line Amplifier may be placed anywhere along a 4 Wire circuit to provide:

- Level control (gain or loss)
- Impedance matching
- Amplitude equalization (RCV path post equalization)
- Simplex signaling leads

wherever needed.

RCV and XMT Separation

Because the 4 Wire Line Amp is used exclusively on 4 Wire circuits, RCV and XMT paths are conditioned separately. This improves transmission characteristics significantly, and a 4 Wire Line Amp is much more stable than a 2 Wire Repeater.

Impedance Matching

Since most 4 Wire Line Amps provide full impedance matching, they can be interfaced with a wide variety of facilities. You may set impedances for all 4 ports — XMT IN and OUT and RCV IN and OUT — as follows:

600Ω	*1200Ω*
• Non loaded cable • Carrier (high frequency bulk transmission via cable or microwave) • SF signaling units	• Loaded cable

Note

Ordinarily, in a 4 Wire to 4 Wire application, the Line Amp may be called a 44V4 Repeater. If the Line Amp is used in conjunction with a 2 Wire/4 Wire Term Set, the combination can be considered a 24V4 Repeater.

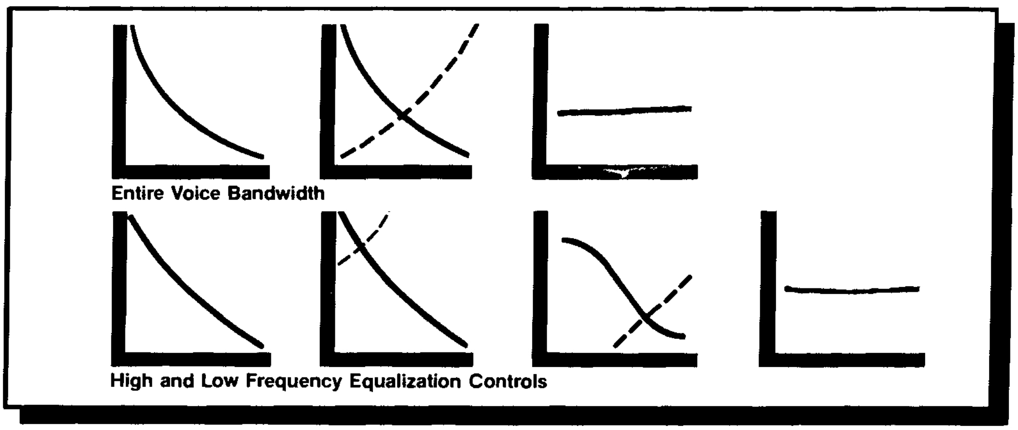
Level Control and Equalization

The two key functions of the 4 Wire Line Amp are level control and equalization. Different modules will vary — on some units you may need to perform equalization first; on others you'll do your amplifying before you equalize. Because of these differences, it's important to check each installation Practice before you begin.

Adding Gain or Attenuation

Different Line Amps may have different gain ranges. You should be able to add either attenuation or gain by adjusting the module's gain control settings. You can make these adjustments with variable potentiometers or by multiple DIP switches. Again, there is no standard mechanism for adding gain, so you'll have to look over the module and check the Practice before you start.

Illustration: Equalization



Equalization Alternatives

Equalization procedures are not the same for all Line Amps either. Although you're performing the same function — getting rid of loss in high frequencies (to the extent required by your Engineering CLR) — you may have to equalize for the entire voice bandwidth (top diagram) or you may need separate adjustments for low frequency and high frequency signals (bottom diagram).

Post-Equalization

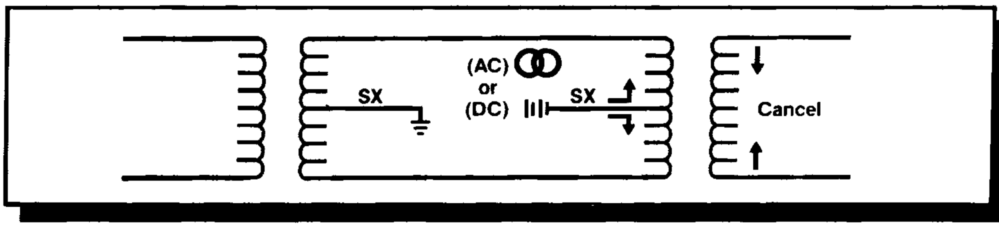
In the vast majority of cases, it really only makes sense to equalize the RCV path of a 4 Wire Line Amp. This is called post-equalization. By performing post-equalization, you're conditioning the signal *after* it's passed through the facility. Thus you're getting rid of the high frequency drop-off at the most critical point, just prior to RCV amplification.

We don't recommend pre-equalization (XMT path) since it is a very complicated procedure requiring remote level readings. Plus, pre-equalization tends to over-amplify high frequency signals, making them conducive to crosstalk. Once in a while though, XMT equalization may be required.

Signaling Review

We just saw how DC signaling was carried on the 2 Wire side of a Term Set by A&B leads. The A&B leads, which originate from the hybrid's coil windings, provide DC signaling without affecting the quality of audio transmission. With 4 Wire circuits, Simplex (SX) leads allow for the same quality of DC signaling.

Illustration: Simplex Leads



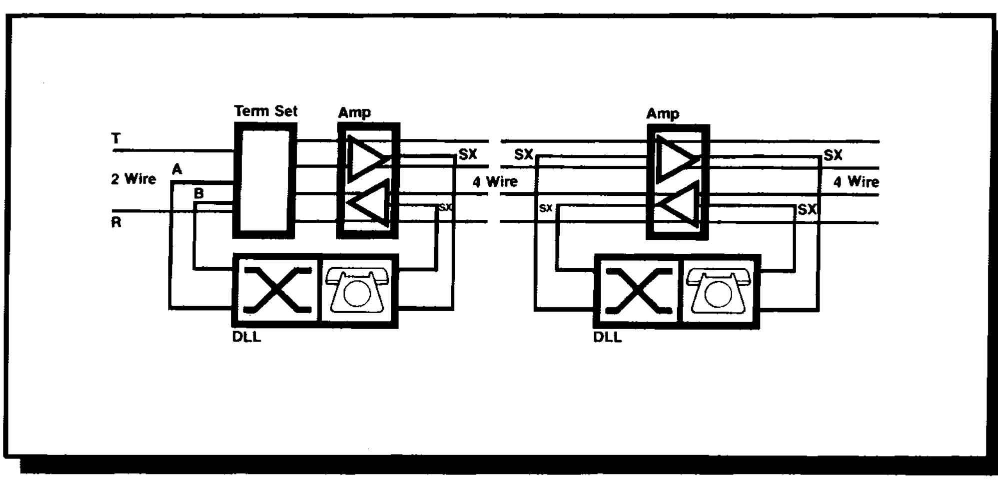
Explanation: Simplex Leads

The Simplex (SX) leads are center tapped from the coil windings of the Line Amp's transformers. SX leads provide total signaling isolation. Because the center-tapped leads allow induced fields to cancel each other out, nothing happens to signaling, ringing, etc. as these signals pass around the transformers.

Application: Transmission and Signaling

One common means of extending loop signaling range as well as amplifying transmission is shown below. A Term Set and 4 Wire Line Amp handle transmission — converting 2 Wire to 4 Wire — while a DLL is installed to strengthen the DC loop signaling. A&B leads from the 2 Wire side go into the DLL. DLL output is recombined with the 4 Wire side through Simplex leads which connect at the distant end of the 4 Wire device.

Illustration: Line Amp and DLL



Exercise 3

First, list the major functions provided by a typical 4 Wire Line Amplifier.

1. ______________________________ ________
2. ______________________________ ________
3. ______________________________ ________
4. ______________________________ ________

Next, after each of the conditioning functions you listed, place the letter which defines that function from the list below:

A. Provide E&M signaling leads

B. Elimination of doubletalk

C. Bypass DC current around Line Amp

D. Maximize Return Loss (Minimize reflections)

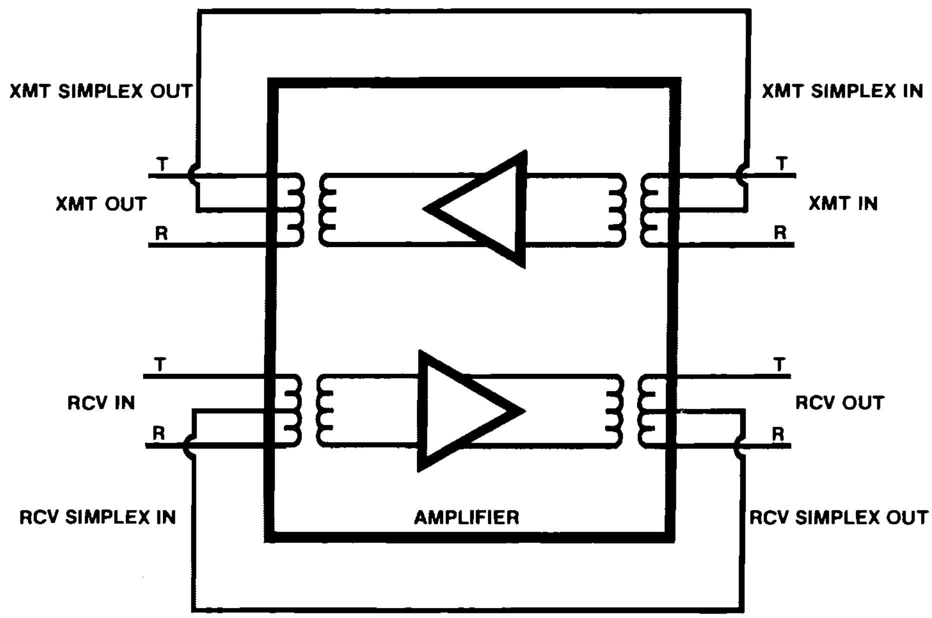
E. Supply-biased Ring Generator

F. Provide loss and gain

G. Correct inadequate frequency response

Exercise 4

Explain the significance of Simplex leads and why they are used in the context of 4 Wire Line Amplifiers.



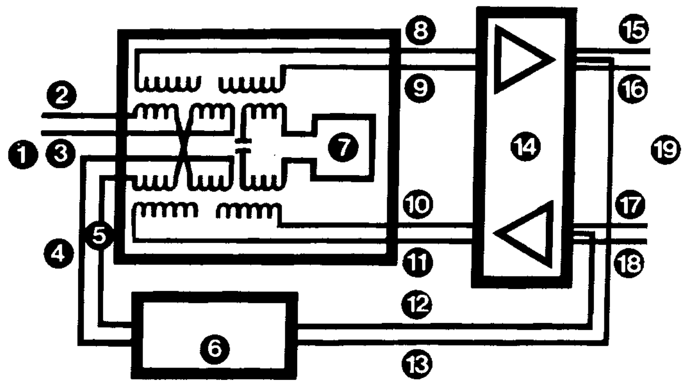
1. What are Simplex leads? ______________________________

____

2. Why are they used with 4 Wire Line Amps? ______________________

____

Exercise 5



In the spaces at left, match the diagram numbers above with the correct terms listed below:

_____ _____ A. Line Amp

_____ _____ B. Transmit Tip

_____ _____ C. Transmit Ring

_____ _____ D. Receive Tip

_____ _____ E. Receive Ring

_____ _____ F. 2 Wire Port

_____ _____ G. A Lead

_____ _____ H. B Lead

_____ _____ I. Balance Network

_____ _____ J. Simplex Leads

_____ _____ K. 4 Wire Side

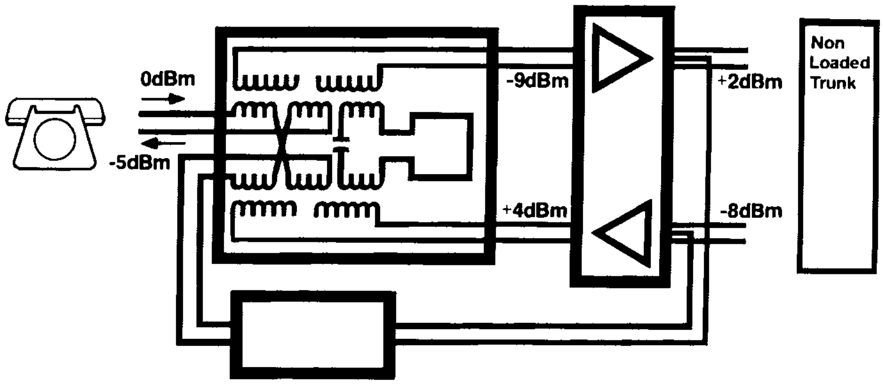
_____ _____ L. 2 Wire Tip

_____ _____ M. 2 Wire Ring

_____ _____ N. The Hybrid device (name it) ____________________

_____ _____ O. The Signaling device (name and number it) ____________

Exercise 6



1. For the circuit shown above, how much attenuation is added by the Term Set to achieve the listed levels?

   ______ Transmit Path

   ______ Receive Path

2. For the circuit shown above, how much gain/loss must be added by the 4 Wire Line Amp to reach specified levels?

   ______ Transmit Path

   ______ Receive Path

3. With a telset as the 2 Wire terminating device, and a non loaded trunk facility at the other end, what impedances should be set for the following?

   ______ 2 Wire Port

   ______ Line Amp Input

   ______ Line Amp Output

4. With that telset/trunk circuit, which supervisory mode should the Dial Long Lines be set for?

   _____ Loop Start

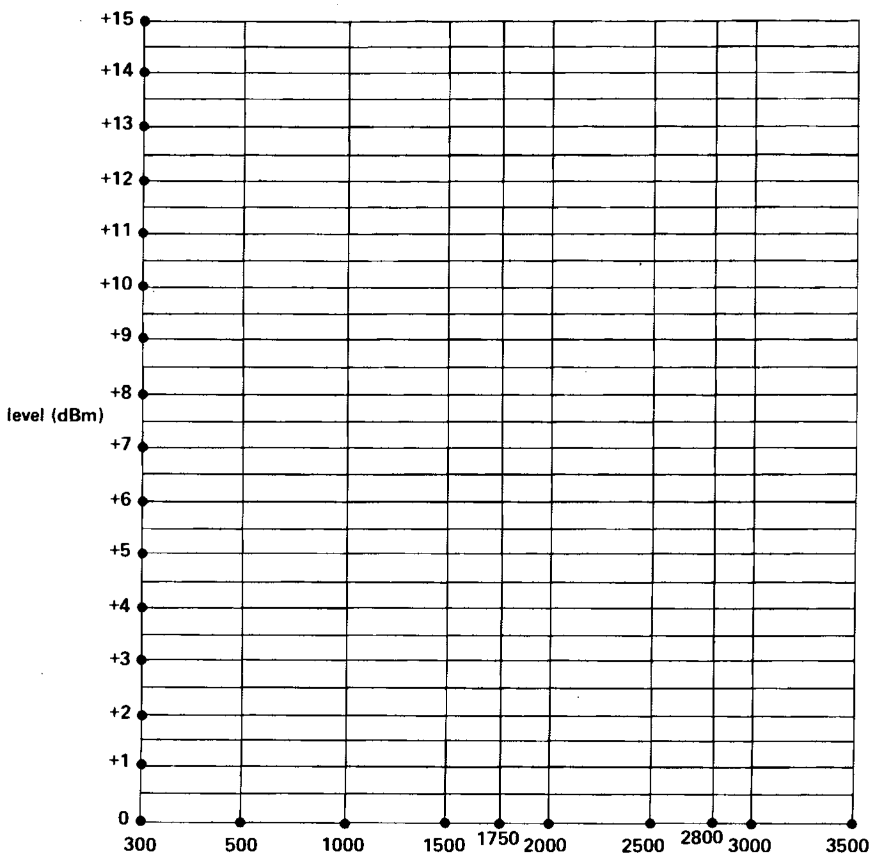
   _____ Ground Start

Exercise 6

equalization exercise

	1	2	3	4	5	6
300						
1000						
3000						

	1	2	3	4	5	6
300						
1000						
3000						



Slope 1:
Unequalized facility with amplifier gain adjusted to a nominal 1kHz level.

Slope 2:
Equalized facility with amplifier gain adjusted to a nominal 1kHz level.

Slope 3:
Equalizer only with amplifier gain adjusted to a nominal 1kHz level.

tellabs

Section 6: E&M and DX Signaling

Instructional Objectives

By the end of this text section you'll be able to:

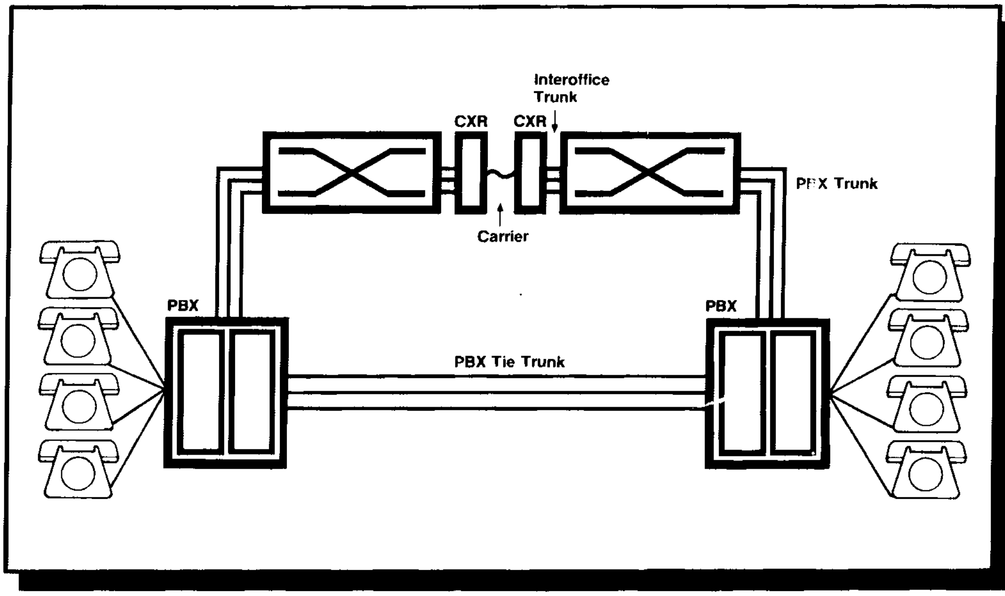
1. Indicate some of the applications where E&M signaling might be used.
2. Analyze a PBX to PBX trunk to identify E&M leads, correlate those leads to appropriate signaling states, and identify the Transmit/Receive function of each lead.
3. Determine E&M leads from given signaling states and determine the circuit's status based on those given states.
4. Select which of a set of three circuit applications might use DX signaling and, in the cases where DX is used, state how the DX configurations would look.
5. Identify DX Signaling and Reference leads when shown an open DX circuit with four voltage readings.
6. List DX1/DX2 optioning for a Carrier-to-Trunk circuit using four DX signaling modules, specify the types of signaling leads used throughout the application, and choose the amount of resistance to be switched into one of the DX unit's Resistive Balance Network.

Table of Contents

Review

Central Offices are connected by interoffice trunk circuits. And PBXs are like private C.O.s which are connected to the serving Central Office by PBX trunks.

Illustration: Trunk Circuit



Application: E&M Signaling

One common method for trunk signaling — that is, signaling between C.O. or PBX switches — uses E&M signaling leads. E&M signaling allows for simultaneous two-way, or duplex, signaling between offices.

Uses of E&M Signaling

E&M signaling is used most frequently on trunk or carrier (CXR) circuits which can access numerous calls at one time. The E&M signaling interface provides a *standard* interface between a variety of switches (C.O.s or PBXs) and facility signaling schemes (CXR, DX (Duplex), SF (Single Frequency), etc.).

E&M Range

The signaling range of E&M leads is extremely short. And that's done on purpose. E&M leads are supposed to provide an interface between trunks and signaling units or between signaling units themselves. The stand-alone applications of E&M signaling are extremely rare.

Advantages of Standardization

But, by providing a standard signaling scheme, E&M leads make circuit engineering a lot easier. By using E&M leads, you don't have to design separate trunk circuits to interface DX, SF or CXR. These all can be used quite easily by means of standard E&M signaling.

Role of E&M Leads

The most important thing to remember when you're dealing with E&M leads is the function of each lead. The E lead is the RCV lead. And the M lead is the XMT lead. This is *always* the case with regard to the closest switch. You can remember these functions as follows:

- E stands for Ear = Receive
- M stands for Mouth = Transmit

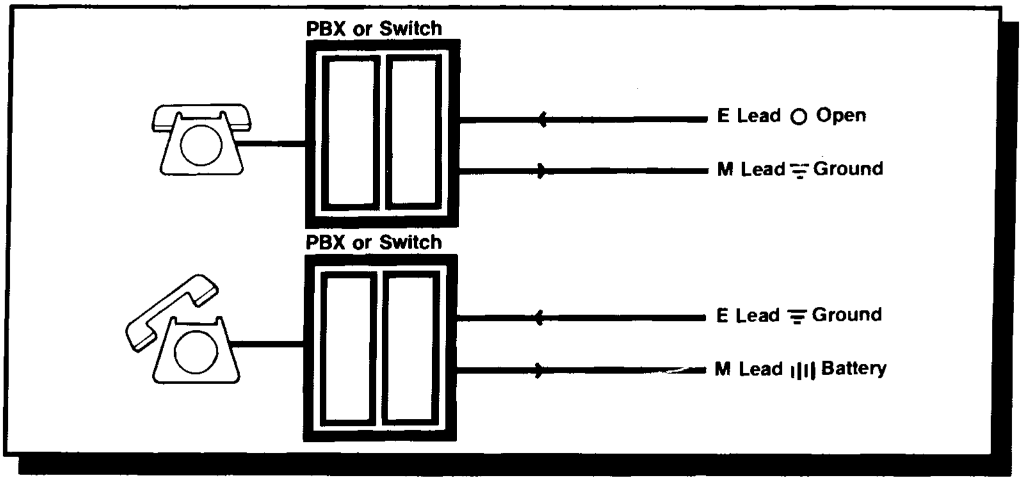
If you keep this mnemonic in mind, you'll always keep your E&M leads straight.

Definition:
E&M Leads

E&M signaling conveys supervisory and dial address information to a switching device using two control leads (E&M).

E&M signaling is duplex — it takes place in both directions — and both ends of the circuit must use compatible signaling units.

Illustration:
Signaling States



Explanation:
E&M States

With a PBX trunk idle (on-hook), the E lead is open and the M lead is at ground.

When the trunk is seized (goes off-hook), the M lead goes from ground to battery. And the E lead goes from open to ground. And the same changes in potential take place during dialing.

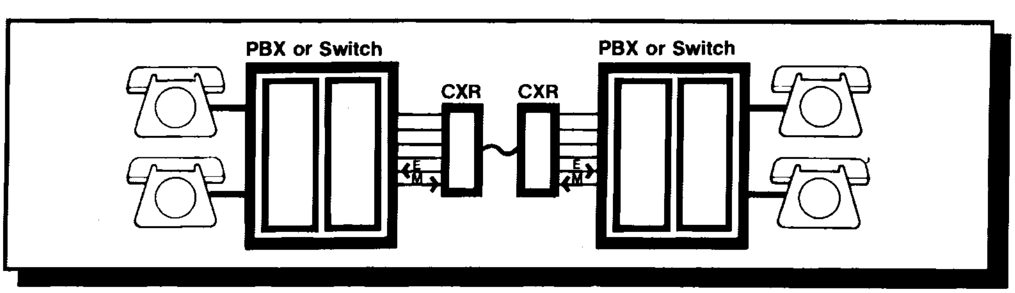
Review

Line Status	*Receive E Lead*	*Transmit M Lead*
Idle	Open	Ground
Busy	Ground	Battery

Note

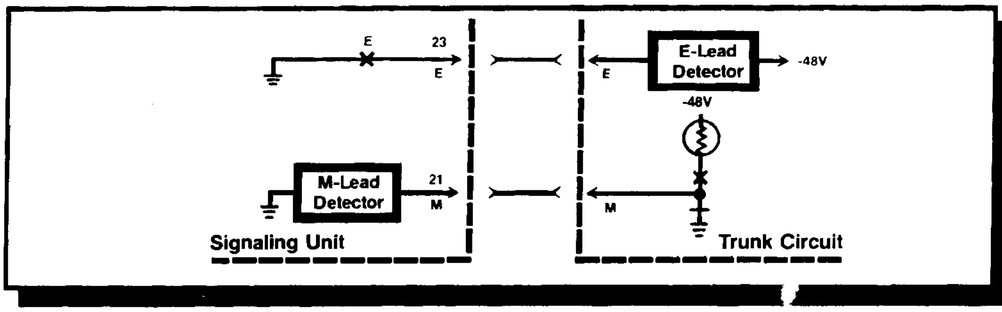
The E lead is input to the PBX or switch. And the M lead is output from the switch. But as you see below, the situation is reversed for either carrier or trunk. Going into the CXR, M is input and E is output. Below, the PBX's E lead is the CXR's M lead.

Illustration:
E&M Input/Output



There are three types of E&M signaling used in different situations.

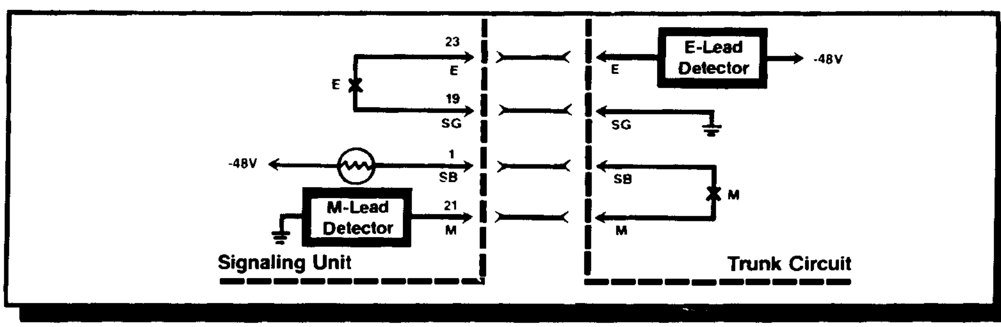
Illustration:
Type I Interface



Explanation:
Type I
E&M Interface

Type I E&M was developed for mechanical switches. The trunk or office equipment provides M-lead battery, while the signaling unit provides E-lead ground. With Type I interface, the trunk circuit and the signaling unit share a common ground.

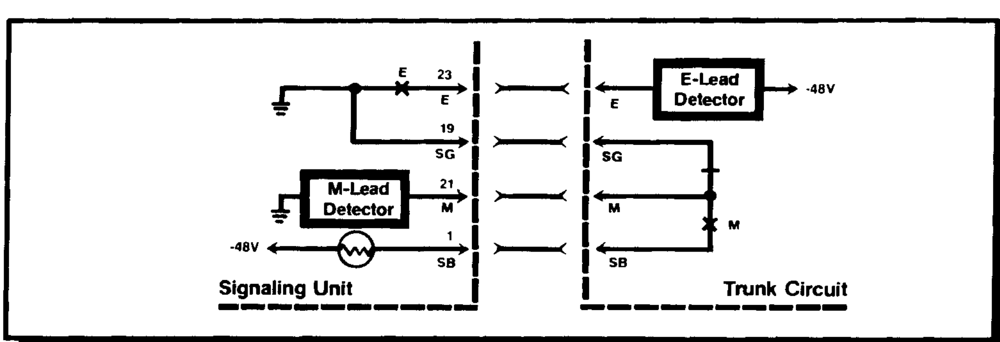
Illustration:
Type II Interface



Explanation:
Type II
E&M Interface

Type II E&M, developed primarily for electronic switching, provides a 4 Wire fully-looped arrangement. The signaling unit provides -48V battery for the M lead, while the trunk circuit provides E-lead ground. Type II interface provides full isolation between trunks and signaling units.

Illustration:
Type III Interface



Explanation:
Type III
E&M Interface

Type III E&M, a rare application, is also used for interfacing electronic switching systems. It provides a compromise partially-looped 4 Wire interface when a fully-looped arrangement can't be provided. In Type III, the signaling unit provides both batteryand ground.

Exercise 1

In the spaces provided at left, indicate with an "X" the three applications where E&M signaling might be used.

_____ 1. C.O. to home phone

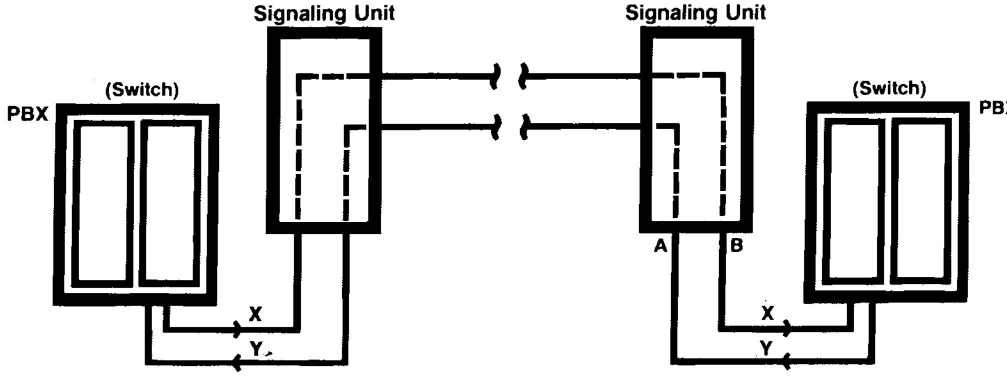
_____ 2. 4 Wire circuit from C.O. to C.O.

_____ 3. PBX to OPS

_____ 4. Carrier to trunk

_____ 5. PBX to C.O.

Exercise 2



1. M lead is ____ E lead is ____

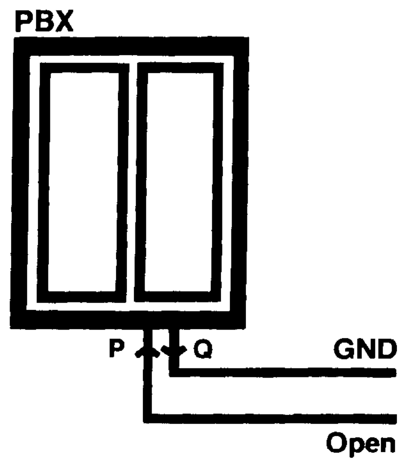
2.

Condition	*M*	*E*
____ Hook	Ground	Open
____ Hook	Battery	Ground

3. To the switch, E is the ______________ lead.

4. To the switch, M is the ______________ lead.

Exercise 3



1. In the space at left, place the letters of the above diagram next to the corresponding components listed below:

   _____ E lead

   _____ M lead

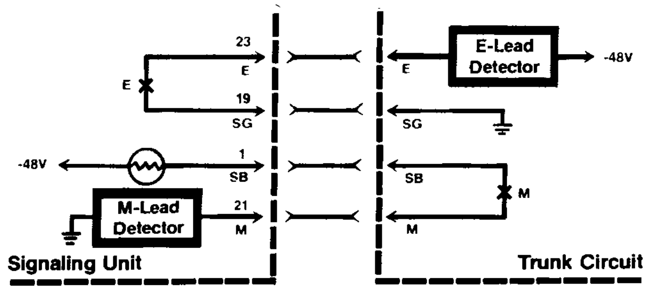
2. Is the circuit above idle or busy? __________

3. If this circuit were in the opposite condition, what would be the states of the E&M leads?

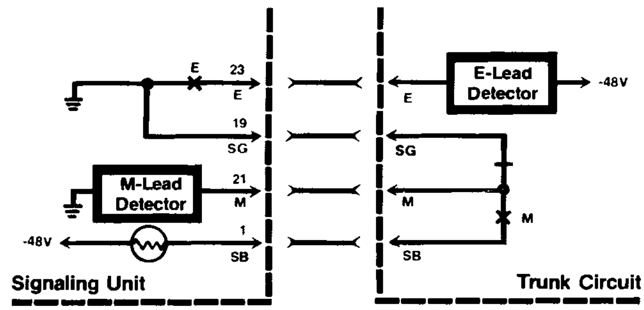
   ______ E lead

   ______ M lead

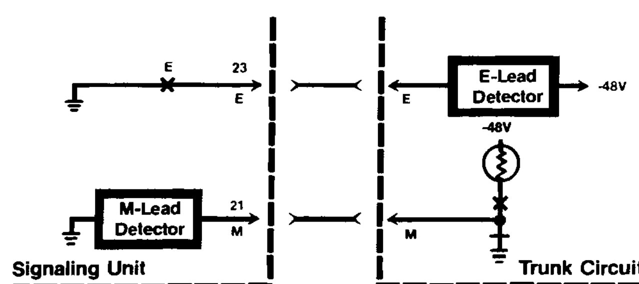
Exercise 4



The above is an example of __________ E&M interface.



The above is an example of __________ E&M interface.



The above is an example of __________ E&M interface.

E&M Review

As we stated earlier, E&M signaling ranges are very short. The new Type I & II interfaces have a range of only 100Ω. And Type III, although not very common, has a range of 300Ω. So, to extend this type of duplex signaling over any reasonable distance, you'll need to use DX signaling equipment.

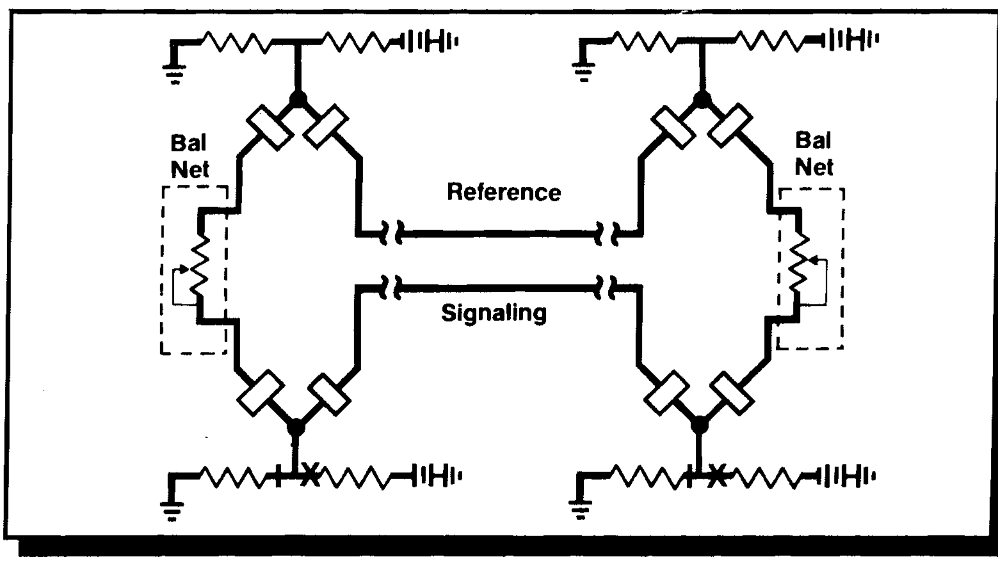
Description: DX Signaling

DX signaling uses a series of relay windings (boxes shown) to convert E&M to DX. DX uses two separate leads — a Signaling lead and a Reference lead — to indicate the E&M states on either side of the circuit.

Definition: DX

DX modules can be used on 2 Wire or 4 Wire facilities, and their range is up to 5000Ω. They are installed on trunk lines or carrier facilities which connect PBXs to Central Offices or C.O.s to C.O.s. Two DX signaling units must be installed in any application to convert E&M signaling to DX at each end of the circuit. Remember, with DX signaling you're still using DC current to extend the range of your E&M leads.

Illustration: DX Circuit

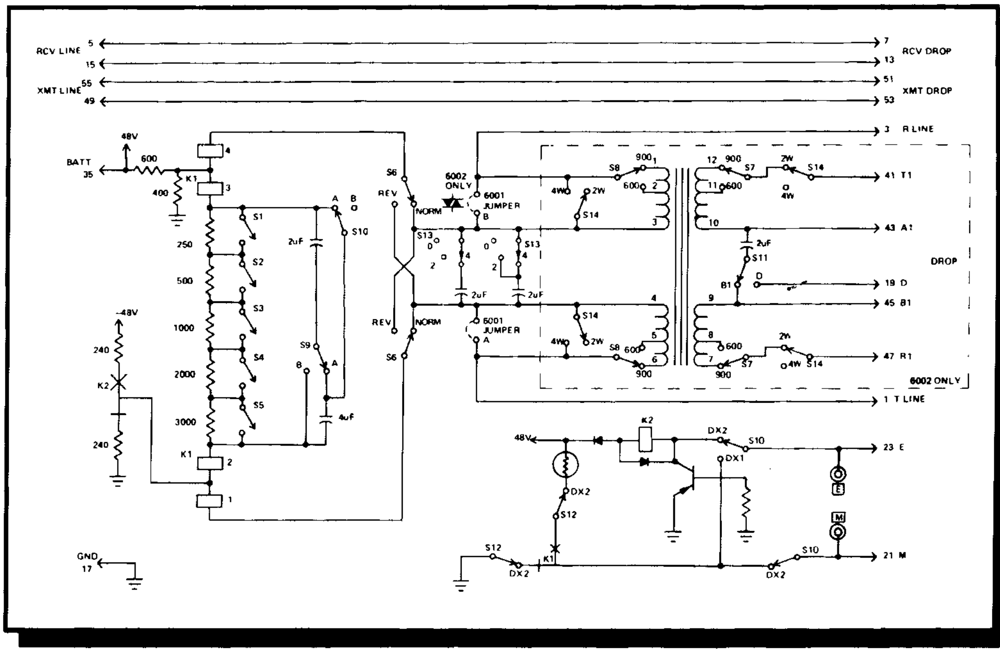


Explanation: Reference and Signaling Leads

The Reference lead compensates for ground or battery differences between either end of the circuit, and it remains constant at about -20V. The Signaling lead voltages will vary depending upon what's happening at either end. You can always identify the Signaling lead if you remember:

- Reference lead is a constant voltage to compensate for differing grounds between units
- Signaling lead's voltage varies as a result of idle/busy states.
- A Signaling lead is always connected to a Signaling lead.
- And a Reference lead is always connected to a Reference lead.

Illustration: DX Block Diagram



Explanation: The DX Balanced Bridge

This is a schematic diagram of one side of the DX circuit you just saw. Necessarily, there will be another identical unit on the other side of the circuit.

Each unit is balanced for the resistance and capacitance of the entire circuit. After balancing, the DX Reference Lead will remain relatively constant, at approximately -20V, and will vary only slightly whether the circuit is idle or busy.

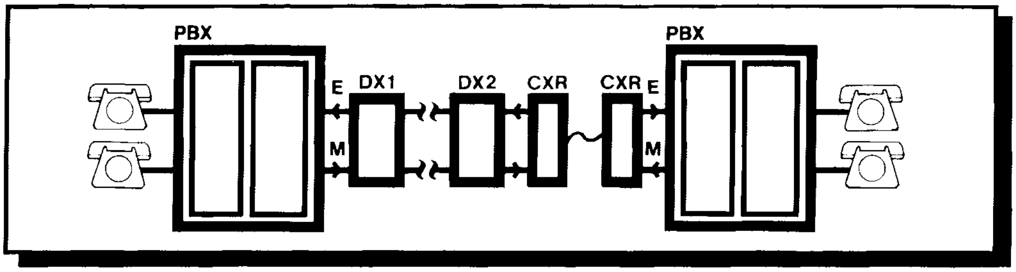
The Signaling Lead will change significantly when either side of the circuit goes off-hook. Changes in E&M lead states will cause a major change in the Signaling Lead's voltage due to the extra resistance of the K1 and K2 relay windings.

Signaling Lead Changes

The Signaling Lead voltage will vary from -1V (idle) to -48V (busy) depending upon loop status and where you make your reading in the circuit. So, if you were to open up a circuit at some intermediate point and measure the Signaling Lead's potential with a VOM, you'd find:

- -1V at idle
- -5V to -24V if distant station is busy
- -24V to -48V if local station is off-hook

Illustration:
DX1/DX2



Explanation:
DX1/DX2

To convert E&M to DX and back again, you need two signaling units. And their set-up will depend on the configuration of the circuit. The most important consideration in installing a DX unit is whether to use it in a DX1 or DX2 signaling mode. Today, most DX modules can be internally optioned for either DX1 or DX2 operation.

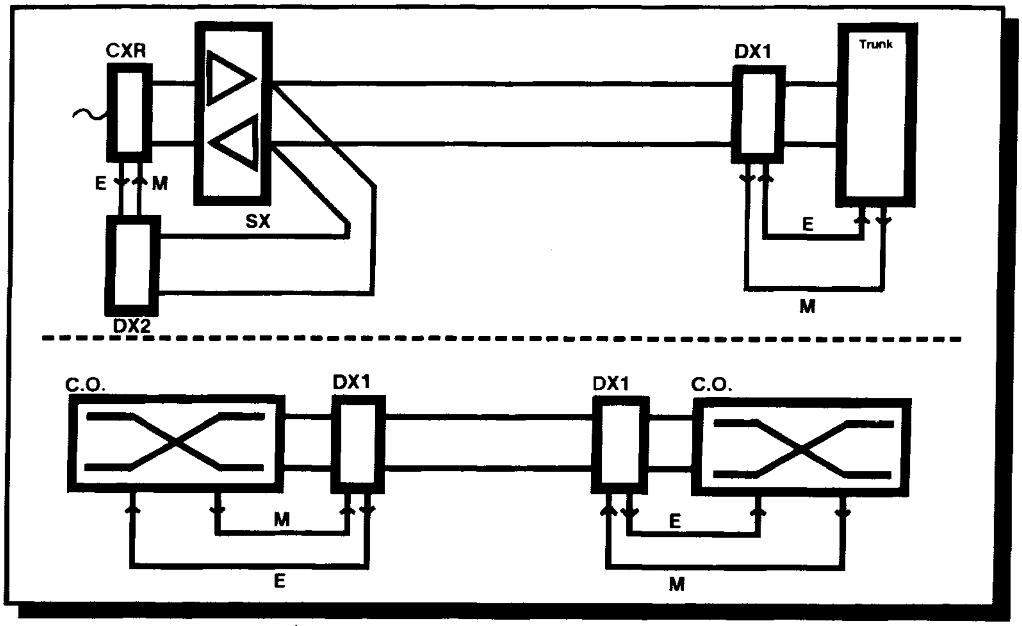
Note:
DX1/DX2
Differences

Most DX units can be set for DX1 or DX2 operation. To determine how your DX unit should be set, just remember:

- DX1 has M-lead inputs/E-lead outputs and
- DX2 has E-lead inputs/M-lead outputs or:

For	*DX Input*	*Option*
Switches, PBXs or C.O.s	M lead	DX1
Signaling unit or CXR	E lead	DX2

Illustration:
DX Applications



Application:
DX1/DX2

The key concept to remember is this: If the DX set's E&M leads are connected to terminal equipment (i.e., a C.O. trunk, PBX trunk, etc.), option for DX1.

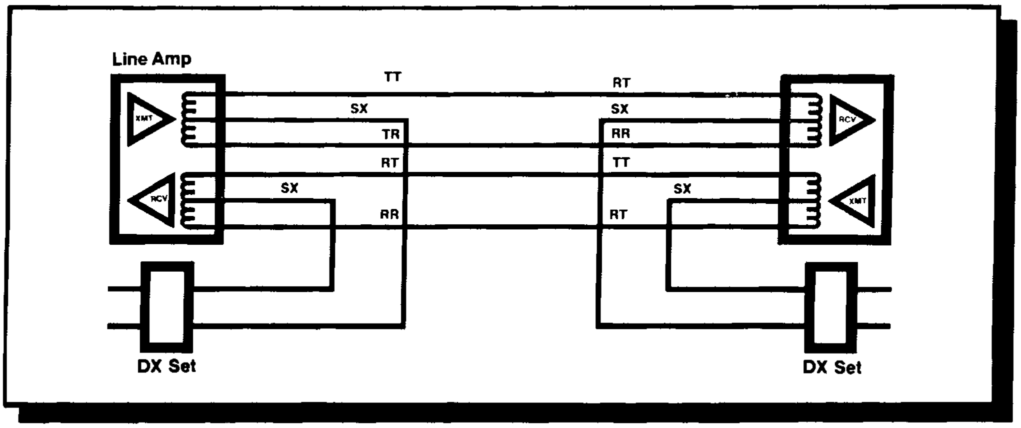
If the DX set's E&M leads are interfacing another signaling medium (i.e., a DX set, SF set, carrier channel, etc.), option for DX2.

For tandem (mid-circuit) operation, two DX units are required. One must be optioned DX1 and the other optioned DX2. Or vice versa.

DX with 2 Wire and 4 Wire Circuits

As you just saw, DX signaling units are often used in a circuit with Line Amps or other transmission devices. In cases where DX outputs are connected directly to Line Amps, the DX outputs are connected via center-tapped Simplex leads. In 2 Wire applications, the outputs are connected via A&B leads. In no cases are the DX leads connected directly to Tip and Ring.

4 Wire DX



2 Wire DX

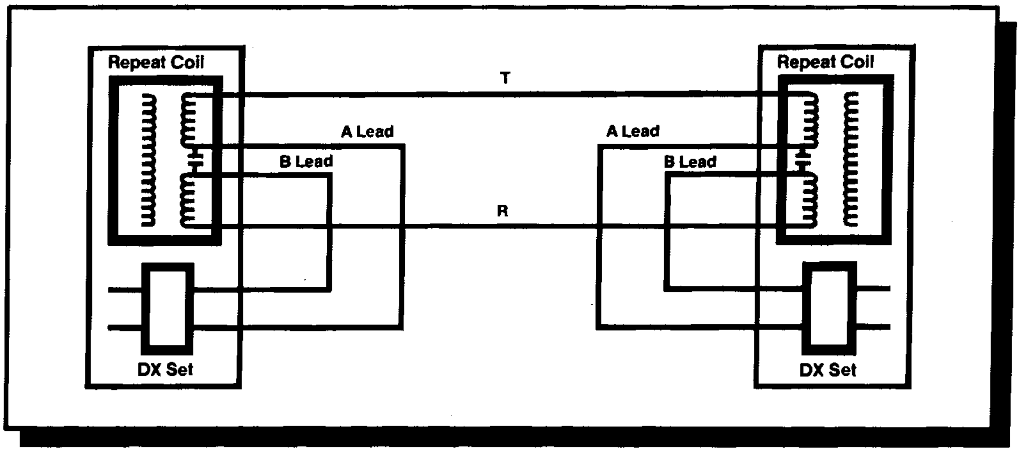
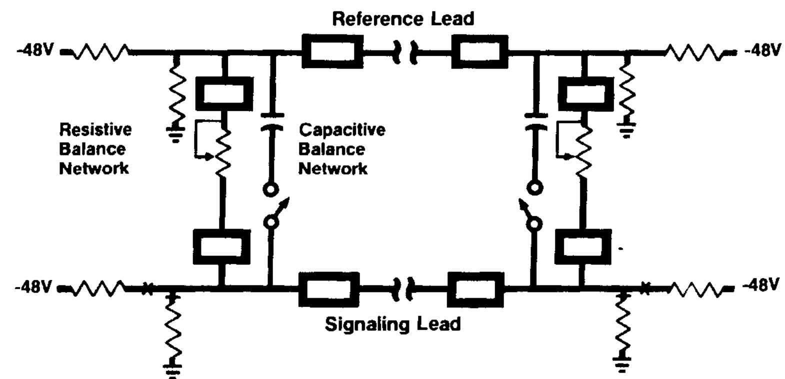


Illustration: DX with Balance Networks



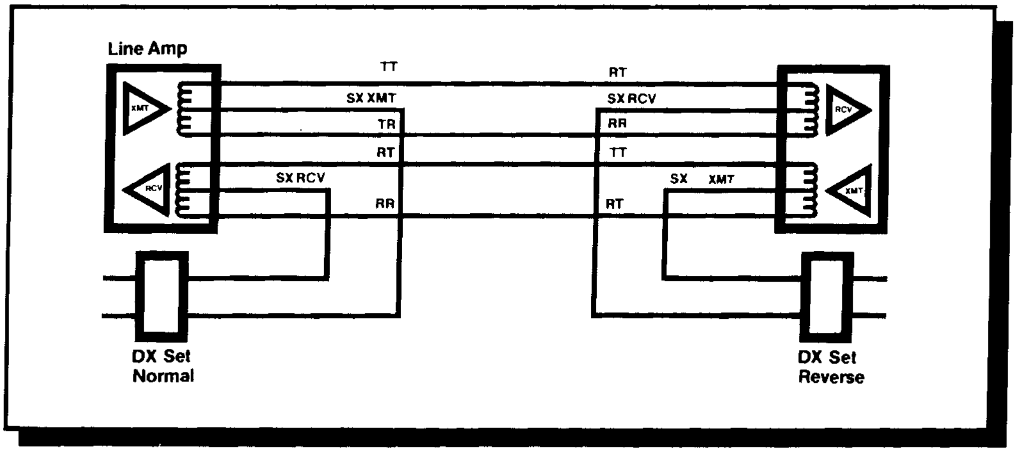
Explanation: Resistive Balance Networks

A pair of DX signaling units is a balanced bridge. And as such it must be resistively balanced against the total resistance of the loop (plus the signaling unit) to accurately measure changing potentials. When used in 4 Wire SX applications, the signaling loop resistance can be calculated as 1/2 the loop resistance of either the XMT or RCV pair. The 2 Wire signaling loop resistance is as measured or specified. For some DX units, up to 6750Ω of resistance may be switched into the balance network in 250Ω increments. Some other modules, however, may already have 1250Ω internal resistance switched in.

Note: Balance Network Capacitance

DX units must also be balanced for facility capacitance. For 2 Wire DX, this figure can be obtained by adding cable capacitance (usually .083μF/mile) plus the capacitance added by any transmission devices in the circuit. For 4 Wire DX, only the capacitance added by transmission devices need be considered, because the capacitance between pairs is negligible. For some DX units, up to 7μF of capacitance can be switched into the balance network. But these amounts will always vary depending upon the module. So again, check the Practice carefully before installing.

Illustration: Reverse/Normal



Explanation: Reverse/Normal

Since you'll be using standard wiring schemes or combined function modules for installing DX circuits, there's one more important option you should be aware of.

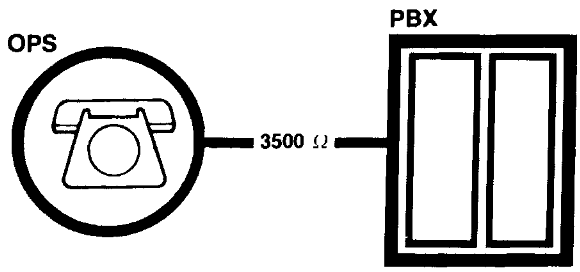
For 4 Wire DX circuits, one of the DX modules — it doesn't matter which one — must be set for NORMAL operation and the other for REVERSED operation. It doesn't matter which unit is optioned for either setting. Just be sure to option them differently to ensure proper Signal/Reference lead connections. If you have any doubt, measure the open circuit voltage and option your local unit accordingly.

Network Termination

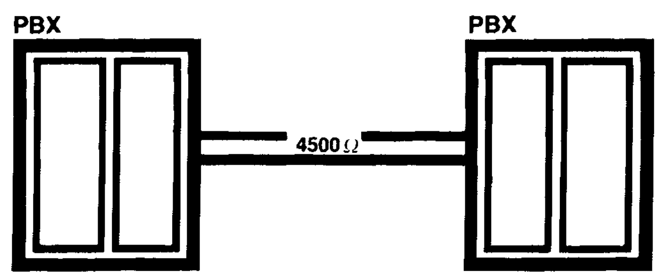
Because DX signaling provides extended loop signaling capability, you'll often be using DX modules in conjunction with a transmission device — a Repeater or Amplifier. Some DX signaling units have Line Amps or Term Sets built into them. These are called Network Terminating modules. They are installed pretty much the same as separate units. But because they're multiple modules in one, you can perform transmission conditioning — equalization and amplification — at the same time you're setting up the DX signaling loop. This makes for a much easier installation, and one Network Terminating module takes up less space than separate Line Amp and DX Signaling modules.

Exercise 5

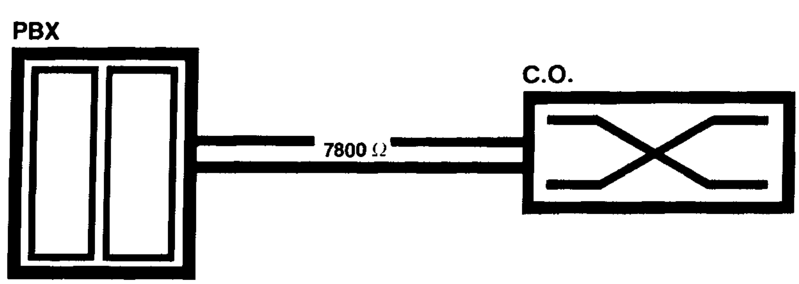
When shown three sample circuits, state which ones need DX signaling and which do not.



1. Would this circuit require DX signaling? ______________________

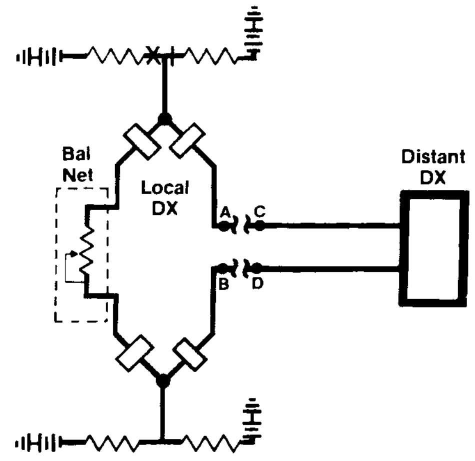


2. Could this circuit use DX signaling? ______________________



3. Could this circuit use DX signaling? ______________________

Exercise 6



1. You've opened up a DX circuit and have connected a VOM at points A, B, C and D to try and determine which lead is the Signaling lead and which lead is the Reference lead.

   Place an "S" in the space below for Signaling lead.
   Place an "R" in the space below for Reference lead.

   _____ Lead A reads -2V

   _____ Lead B reads -21V

   _____ Lead C reads -24V

   _____ Lead D reads -23V

   How did you decide? ______________________________

   ____

   What is the condition? ______________________________

   ____

2. You're working with a new DX circuit now. You open it up and get VOM readings:

   Now place the appropriate "S" for Signaling lead and "R" for Reference lead.

   _____ Lead A reads -1V

   _____ Lead B reads -17V

   _____ Lead C reads -17V

   _____ Lead D reads -1V

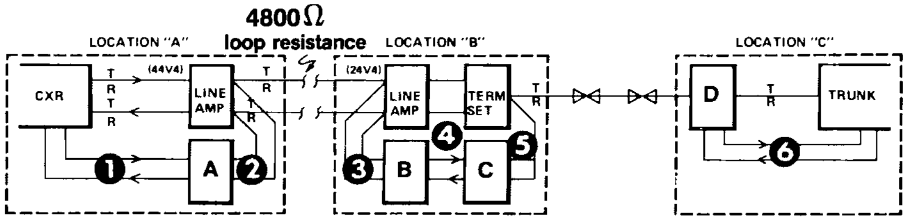
   Is there a problem? How do you solve it? ______________________________

   ____

   ____

Exercise 7

1. For the circuit shown below, specify which DX units should be set for DX1 and which for DX2. Also, specify E&M leads, SX leads and A&B leads where used.



DX1 *DX2*

_____ _____ DX Unit A

_____ _____ DX Unit B

_____ _____ DX Unit C

_____ _____ DX Unit D

_____ Signaling Lead 1

_____ Signaling Lead 2

_____ Signaling Lead 3

_____ Signaling Lead 4

_____ Signaling Lead 5

_____ Signaling Lead 6

2. If the resistance of one pair of the 4 Wire facility between the 44V4 Repeater and the 24V4 Repeater is 4800Ω and the DX Unit A has non-compensated internal resistance of 1250Ω, how much resistance must be switched into the DX Unit's Resistive Balance Network to correctly install the module?

_____ A. 6050Ω

_____ B. 4800Ω

_____ C. 1250Ω

_____ D. 3650Ω

_____ E. 6750Ω

tellabs

Section 7: SF Signaling

Instructional Objectives

By the end of this text section you'll be able to:

1. State why SF signaling is unique, select the level and frequency associated with SF, and specify corresponding SF level when shown a Transmission Level Point (TLP).
2. Identify the three types of signaling used in a sample circuit.
3. Indicate Transmission Level Points (TLPs) for a circuit involving a Line Amplifier, SF Transceiver, Signaling Converter and Term Set.
4. Explain accidental talk-off and the processes used to prevent it.
5. Select the proper function of the CT relay from a list of alternatives.
6. Identify four SF applications from a list of Special Service circuits.
7. Determine SF tone states for a Loop Start FXO/FXS circuit and idle condition tone states for both Loop Start and Ground Start FXO/FXS.

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Review: E&M and DX

DX signaling is one method for providing extended duplex signaling over metallic facilities. It uses DC current to extend the range of standard E&M signaling leads. The difference in direction and amount of DC flow between the DX Signaling and Reference leads communicates idle, busy and dialing states quickly, efficiently, and over quite a long distance. But eventually, DX requires too many signaling devices and costs too much money.

SF Rationale: In-Band Signaling

In even longer 4 Wire circuits, especially those involving microwave carrier facilities, it's desirable to convert DC signaling to an AC frequency that can be carried right along with voice transmission. This is referred to as in-band signaling because the signaling frequency lies within the normal VF bandwidth.

In Special Services, this type of AC signaling is called Single Frequency (SF) signaling — a 2600Hz tone whose presence or absence indicates idle, busy or pulsing states. Between C.O.s, other frequencies may be used (multiple frequencies or MF), but, in principle, all in-band AC signaling works about the same.

Note: Inherent SF Differences

Unlike the other signaling formats discussed thus far — Loop, E&M or DX — SF tone normally is present whenever the phone is on-hook or the circuit is idle . The SF tone is removed whenever the phone goes off-hook or the circuit is seized. This is quite logical when you consider that SF tone travels along the *transmission* path. Obviously, you don't want SF tone to be present when you're talking over the circuit.

To begin with, we'll be discussing the SF interface with E&M signaling, since this is the simplest and most common application. However, SF can be used in Foreign Exchange or Ringdown situations as well as with E&M. But in the latter cases, the formats are slightly different. We'll describe these different applications a little later in this text section.

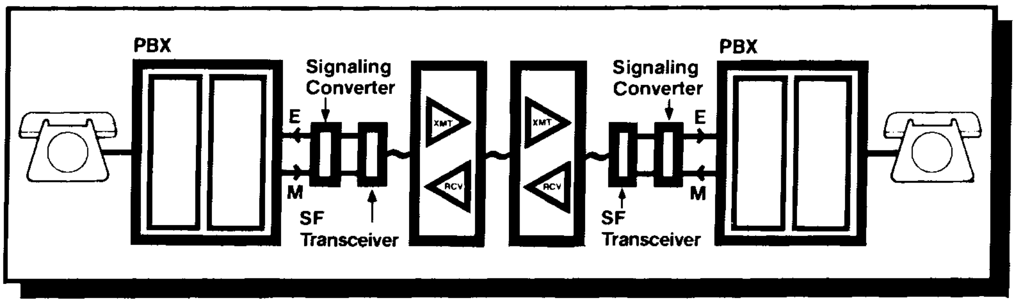
SF Advantages

- Signaling with AC — no DC path required
- Signaling over long lines (satellite, microwave, radio, etc.)
- Signaling over CXR channels
- Signaling through tandem points (distant C.O.s) without conversion

SF Disadvantages

- Some time delay in signaling
- Possibility of accidental interruption of voice path (talk-off)

Illustration



SF Modules

SF signaling involves two different devices, with one of each located at either end of the extended circuit. The Signaling Converter takes trunk-side E&M signaling states and converts them to logic-level E&M states. The logic-level states are not the same as the true E&M lead states coming out of a PBX; instead, they are used solely to communicate between Signaling Converters and Transceivers. Then the SF Transceiver translates logic-level M lead states to outgoing SF tone, and processes incoming SF tones to logic-level E lead states. Increasingly, you'll find both Signaling Converters and SF Transceivers built into the same module. With these newer devices, DC signaling is converted directly to SF on a single card.

SF Frequencies

As we said, SF signaling takes the form of a tone of one frequency, most commonly 2600Hz. This tone is transmitted at a level (-20dBm0) 20dB less than the alignment level (TLP). So, the SF tones can be boosted by a standard Line Amp right along with normal voice information. Because the tone is sent along with voice, special circuitry must be built into the unit to prevent the SF Transceiver from confusing voice with SF tone and accidentally terminating the call.

Note

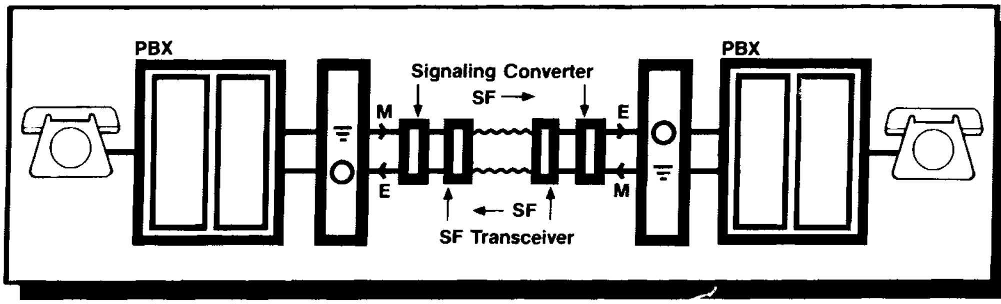
For all SF applications, the SF Transceiver is used to transmit and receive SF signaling tones. Various types of Signaling Converters are used to convert station-side signaling (Loop, DX, etc.) to the logic-level states required by the transceiver. Again, newer modules may combine the converter and transceiver functions in a single unit.

E&M

To briefly reiterate what we learned about E&M signaling:

Station	*E lead*	*M lead*
Idle	Open	Ground
Busy	Ground	Battery

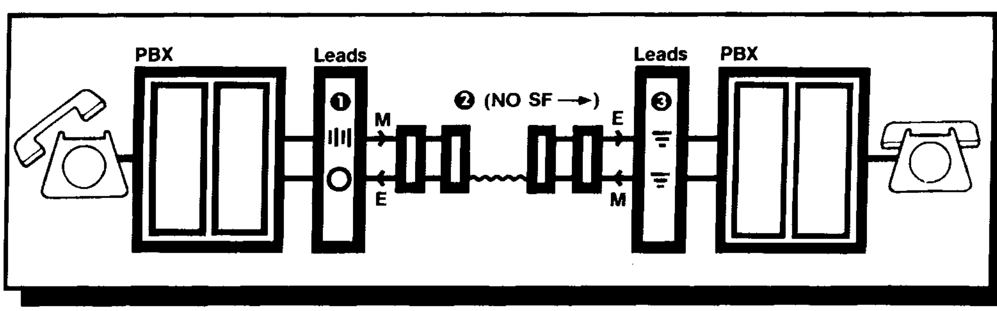
Illustration



Explanation: Idle Circuit

The circuit is idle, so SF tone flows in both directions. E&M states are at Open and Ground respectively as shown.

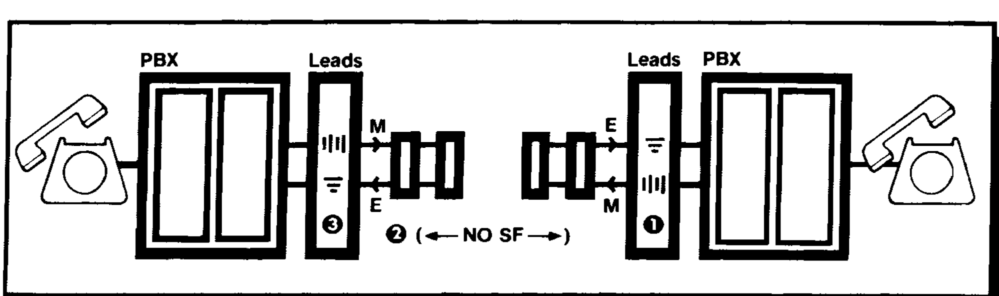
Illustration



Explanation: Calling Party

The calling party (left) goes off-hook and accesses the trunk. This causes its M lead to go from Ground to Battery (1). As a result of this change, the SF Transceiver removes tone (2) and the distant E lead goes from Open to Ground (3). As the calling party dials, a series of battery/ground states becomes a series of SF on/off tone conditions.

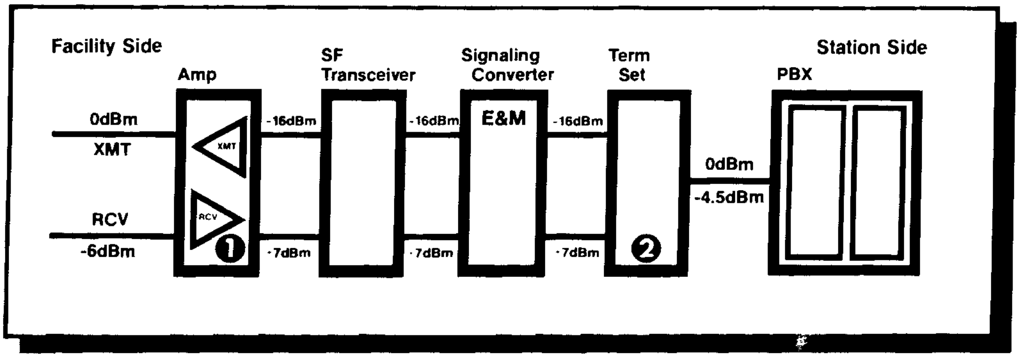
Illustration



Explanation: Seized Circuit

Here, the called party finally answers and goes off-hook. This causes its M lead to go from Ground to Battery (1), a cessation of SF tone to the calling party (2), and a switch of that station's E lead from Open to Ground (3).

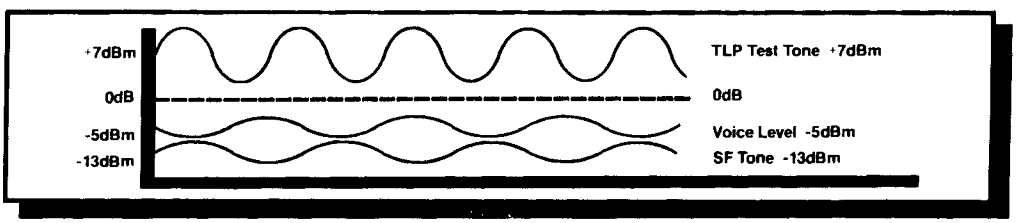
Illustration



System Configuration

Often you'll run into an installation like the one above. That is, the SF signaling module will be sandwiched between a Line Amp (1) and a Term Set (2). The alignment levels shown are hypothetical ones, but they approximate what you're apt to see in the field. Between SF units, you'll *always* see the standard TLPs of -16dBm XMT and +7dBm RCV. But remember, the SF tone itself will be going out about 20dB lower than those specified levels.

Illustration: SF = -20dBm0



Installation Note: CT Relay

When SF tone is transmitted, the Cut and Terminate (CT) relay opens the XMT path so that no other noise, voice, etc. is associated with SF tone. Also, the tone is initially sent at a momentarily higher level to make sure that it is detected at the other end *(augmented SF)*. So, when you align the XMT side of your modules, you must busy the circuit, remove the Signaling Converter, in order to perform your alignment. Otherwise, the CT relay will detect SF tone and cut and terminate the circuit in 600Ω.

When aligning the XMT channel, you work your way *out* from the station side (Term Set) to the 4 Wire facility. On the Receive channel, you do just the opposite. On RCV, work in from the 4 Wire facility toward the station side.

Pulse Correction

Although there is some pulse correction built into the Signaling Converter, you may have to add a Precision Pulse Corrector if the incoming dial pulses warrant it. Your circuit Engineering Record will probably specify the Precision Pulse Corrector. And you'll have to option the module accordingly.

Talk-Off

The SF Transceiver also contains special SF detection circuitry to prevent talk-off. That's the accidental termination of a call due to the recognition of the 2600Hz components of speech, at the appropriate level (-20dBm0) and for a specified time duration. When these transmission conditions are present, the unit officially recognizes it as SF tone and terminates the call. But because of the frequency level and time considerations of the talk-off circuitry, it's virtually impossible to cause termination by accident of speech.

Exercise 1

State why SF signaling is unique among the other signaling methods discussed so far.

1. Why is SF signaling unique? ______________________

2. Place an "X" beside the appropriate frequency and level most commonly associated with SF signaling.

____ 1. 260Hz	____ a. -16dBm
____ 2. 4000Hz	____ b. +7dBm0
____ 3. 2600Hz	____ c. +25dBm
____ 4. 1400Hz	____ d. -40dBm0
____ 5. 1200Hz	____ e. -35dBm0
____ 6. 2300Hz	____ f. -20dBm0

3. When given a TLP of +7dBm, place an "X" beside the appropriate SF level.

____ A. +13dBm

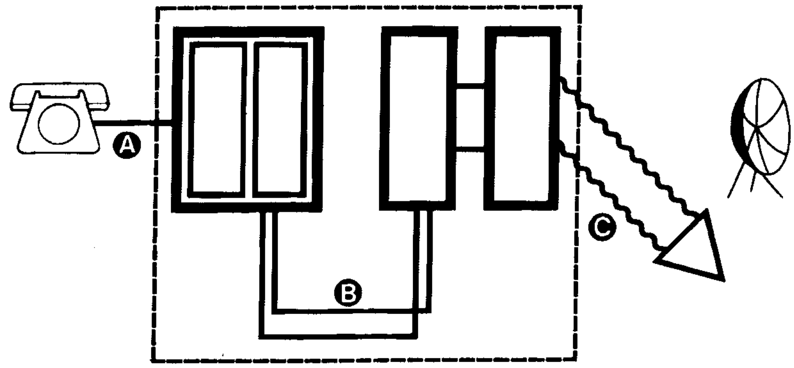
____ B. -13dBm

____ C. -20dB

____ D. -20dBm0

____ E. -36dBm

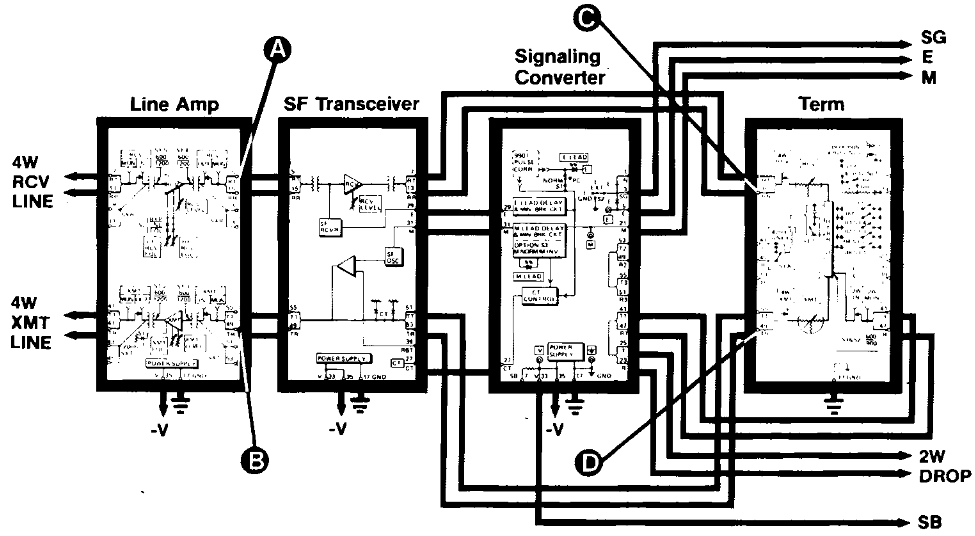
Exercise 2



4. Match the three separate types of signaling being used in the diagram above:

A. __________	W. SF
B. __________	X. DX
C. __________	Y. Loop
	Z. E&M

Exercise 3



1. In the space below, place the appropriate level beside each Transmission Level Point (TLP) indicated in the diagram above.

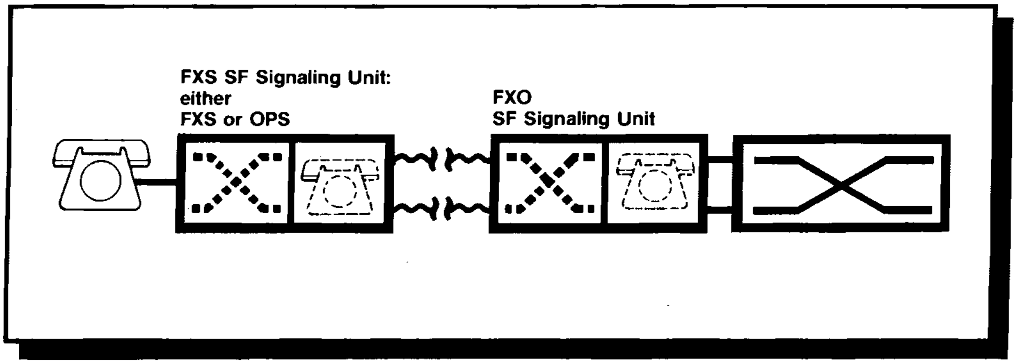
   A. ____________

   B. ____________

   C. ____________

   D. ____________

Illustration: Functional FXO/FXS

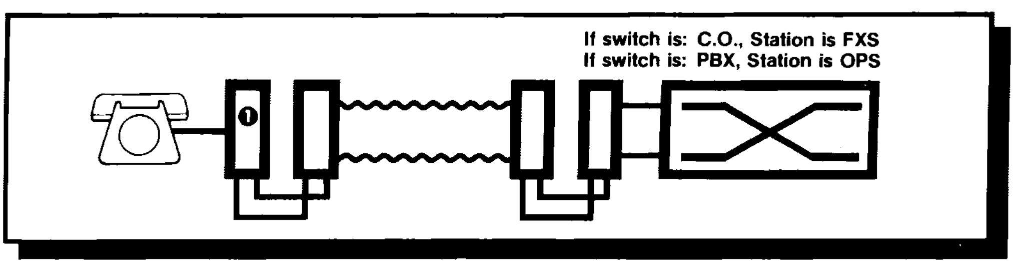


FX and OPS Applications

You may also run into SF systems like these in the field. Foreign Exchange (FX) circuits are those in which dial tone is originated at a distant C.O. For example, a suburban company might have an FX circuit to retain city-originated phone service.

The OPS situation was described before, and that's a case where a PBX controls a telephone at a distant location. In either case, the FXO/FXS modules must perform additional functions like the imaginary circuit above. This arrangement extends the signaling range of circuit, with the FXS module providing traditional telephone functions.

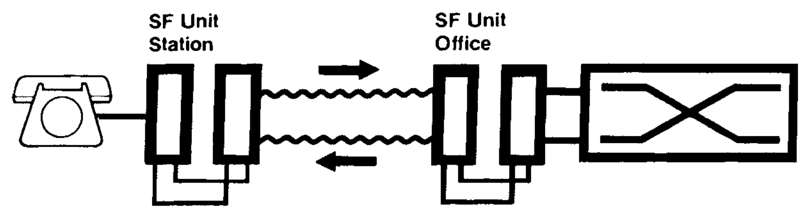
Illustration: FXS/OPS



Explanation: FXS SF Signaling

As we said before, different types of Signaling Converters are needed to convert alternative signaling modes into eventual SF. In the case of FXS SF Signaling units (1), these modules may also supply Ring Generator and Talk Battery for the telephone. So, in effect, this SF application replicates the original telset/C.O. loop, but over extremely long distances.

**Illustration:
Loop Start**

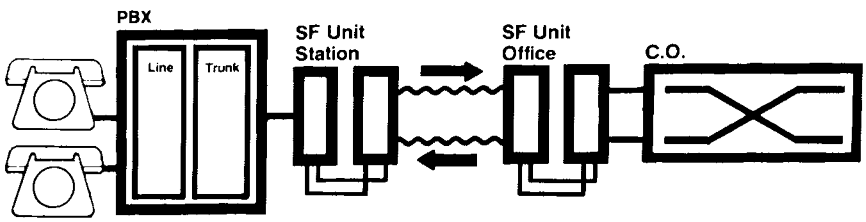


**Explanation:
Station End
Signaling States**

Station	*SF* →	← *SF*
Idle	On	Off
Ringing	On	2 On/4 Off
Off-hook (busy)	Off	Off
Dialing	On-Off pulses	Off

So, SF ← is ON only during ringing.

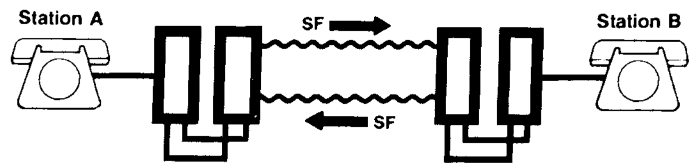
**Illustration:
Ground Start**



**Explanation:
Station End
Signaling States**

	Circuit State	*SF* →	← *SF*
Incoming	Idle	On	On
	Tip Ground	On	Off
	Ringing	On	On/Off modulated @ 20Hz rate
	Off-hook (seized)	Off	Off
Outgoing	Idle	On	On
	Ground Ring	Off	On
	Tip Ground	Off	Off
	Pulsing	On/Off	Off

Illustration: Automatic Ringdown



Explanation: A-to-B Call Sequence

Timed Ringdown

	Station A	SF →	← SF	Station B
Idle	On-hook	Off	Off	On-Hook
Seizure	Off-hook	2 Secs On	Off	Phone rings (2 Secs or 30 Secs)
Answer	Off-hook	Off	Off	Off-Hook

Calling Party Control

	Station A	SF →	← SF	Station B
Idle	On-hook	Off	Off	On-Hook
Seizure	Off-hook	On	Off	Phone rings
Answer	Off-hook	Off	Burst	Off-Hook

Exercise 4

Identify the process by which the SF Transceiver prevents accidental talk-off.

1. What is accidental talk-off? ______________________________

____

2. Place an "X" by the three processes which the SF Transceiver uses to prevent accidental talk-off.

_____ Pulse corrector	_____ CT relay
_____ Frequency	_____ Duration of tone
_____ Ringdown circuitry	_____ -20dBm0

3. In the space at left, place an "X" beside the correct function of the CT relay in an SF signaling device.

_____ A. Converts DX signaling to SF

_____ B. Applies Ring Generator in OFX circuits

_____ C. Corrects SF tone subject to disharmonic oscillation

_____ D. Cuts transmission path and terminates in 600Ω

_____ E. Provides automatic padding to SF signal

Exercise 5

In the space at left, place an "X" beside the four Special Service circuits that use SF signaling.

_____ 1. OPX

_____ 2. FX

_____ 3. Ringdown

_____ 4. Dedicated data circuits

_____ 5. Hoot'n Holler circuits

_____ 6. Subscriber carrier

_____ 7. Automatic dialing

_____ 8. DTMF signaling

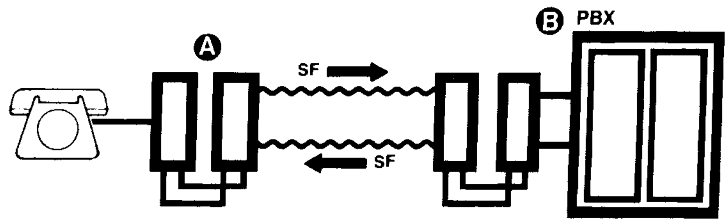
_____ 9. Statistical multiplexer

_____ 10. Alarm bridging

_____ 11. Echo canceller

_____ 12. Hot line

Exercise 6



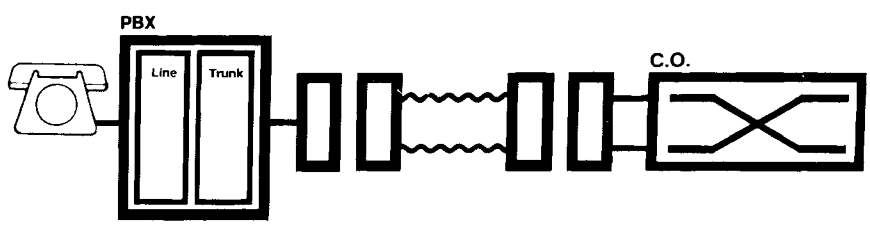
1. The above PBX circuit is a loop start circuit. In the spaces provided, indicate the correct SF tone states for the situations specified.

Circuit	*SF →*	*← SF*
Idle	____	____
Dialing	____	____
Ringing	____	____

Which module is FXO? ____
(A or B)

Is the other an FXS? ____

Or is it OPS? ____



2. SF signaling is often used in FXS (station) and FXO (office) applications, in both Loop Start and Ground Start modes. In the space provided, show the SF tone state for these circuits in the *idle* condition.

FXS	*SF →*	*← SF*
Loop Start	____	____
Ground Start	____	____
FXO		
Loop Start	____	____
Ground Start	____	____

Section 8: How to Use a Practice

Instructional Objectives

By the end of this text section you'll be able to:

1. Recognize the three most important Practice sections from an installation viewpoint.
2. State a module's issue level, its accompanying Practice issue number, the module's manufacture date and its warranty period.
3. List three major features of a module based on its Practice's General Description.
4. Locate where wiring pin connections are specified.
5. Specify option switch positions for an installation based on a Circuit Layout Record (CLR) and the Practice's Options and Alignment section.
6. Identify module components on a block diagram.
7. Propose solutions to installation problems based on the Testing and Troubleshooting Practice sections.
8. Prioritize generic troubleshooting steps for any installation procedure.

Table of Contents

What is a Practice?

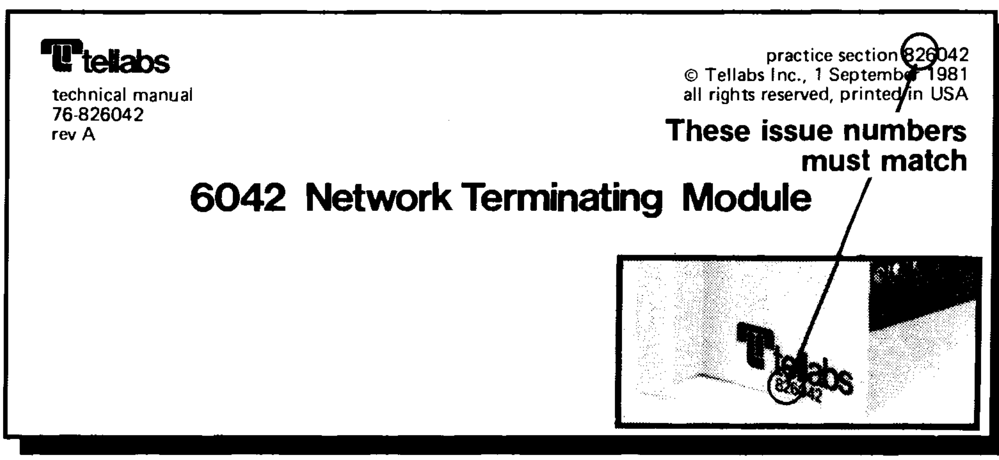
Your technical Practice is your most important installation tool. Equipment manufacturers take great pains to tell you everything you need to know in order to install that particular piece of gear.

But it does take some time and some familiarity with the Practice to find exactly what you're looking for. On top of that, different manufacturers use different Practice formats. That's why, in this text section, we'll show you how to use a Tellabs Practice. After that, you'll probably be better able to find what you're looking for in other types of Practices as well.

Who reads Practices?

Most installation trouble calls concern problems covered somewhere in our technical Practices. The problem is that Practices are not always read. That's because most Practices are not aimed strictly at installers. Engineers, Managers and Purchasing Agents all may read a Practice looking at features and benefits, potential applications, wiring diagrams or manufacturing specs. Installation information is included in there. But you have to know where to look. Also, you have to be able to understand the information that's important to you and not be put off by the technical language.

Illustration



Issue Levels

Tellabs Practices are created for each individual product and are shipped out with each module when they leave the factory. But human error can take place, so it's important to check that the right Practice has been shipped with the proper product. Match the Practice Section number in the upper right corner of the Practice cover with the issue number on the bottom of the module's front panel. The second digit in this case, 2, is the product's issue number. It's absolutely essential that the issue number on the product is the same as on the Practice. If they match up, you're in business. If not, don't go any further because you're going to have a problem.

Part Numbers

Before you start an installation or begin to read a Practice, it's a good idea to know the type of product you'll be dealing with. Tellabs has its own product numbering system which tells you what functions our various products perform. This is not a universal numbering system, but it is a useful guide for one vendor's — Tellabs — products. The initial 8 number on each module is for internal use only.

Prefix	*Function*
1XXX	Mountings and Apparatus Cases
2XX	Prewired Systems
3XX	Voice and Data Systems
4XXX	Amplifiers, Equalizers, Terminating Modules
6XXX	Signaling and Trunk Modules
7XXX	Loop Treatment
8XXX	Power and Ringing
9XXX	Miscellaneous Modules and Sub-Assemblies

Warranties

Next, it's a good idea to know if the module you're working with is in warranty. That way, in the rare case that your product turns out to be defective, you can return it to the vendor. All Tellabs standard products have a 5-year limited warranty from the date of manufacture. And the manufacture date is stamped on the circuit board of each Tellabs module.

Illustration

6942 4Wire E and M SF Signaling Set

contents

Table of Contents

Each Tellabs Practice includes a Table of Contents as shown above. Although you will probably be most interested in Sections 3, 5 and 7 — Installation, Block Diagram and Testing/Troubleshooting — it's probably a good idea to look over the other Practice sections too so that you can have an idea of what the equipment does and what its most common applications are apt to look like.

General Description

Practice Section 1 gives you a general description of the product you'll be working with. It lists the features and benefits of that module and provides a functional overview. When you're on an installation call, you might not have time to read this section carefully. But, depending upon your own personal motivation, you may be curious to learn more about what you're installing. Section 1 gives you that chance.

Illustration: General Description and ARD Modules

1. **general description**

1.01 The 6003 and 6004 Two-wire Automatic Ringdown modules provide automatic ringdown (ARD) service between two stations or PBX trunks. Either module causes ringing to be applied to one end of a circuit in response to a station off-hook or PBX trunk seizure at the opposite end. One module per circuit provides automatic ringdown service in both directions. Ringing, once initiated, continues until the called party answers or until the calling party goes back on-hook.

1.02 The 6004 differs from the 6003 in that it incorporates a relay to allow the externally controlled transfer of the ringdown function at one end of the circuit between two station loops or PBX trunks, as may be required, for example, to implement a night service hookup. The 6003 does not include this transfer relay.

1.03 All normal 2wire signaling and battery feed functions for loop status detection, ringing application, ring tripping and audible ringback are implemented by the 6003 or 6004 module through standard loop signaling techniques.

1.04 Either module may be switch optioned for loop start or ground start operation in either or both directions. Seizure of the circuit, which causes the 6003 or 6004 module to apply ringing toward the opposite end of the circuit, is accomplished in the loop start mode by the detection of loop current resulting from an off-hook telephone instrument. In the ground start mode, seizure is accomplished by the detection of ground on the ring conductor of the subscriber loop.

1.05 Interrupted ringing may be provided by either 6003 or 6004 Ringdown module through use of the optional 9903 Ringing Interrupter subassembly. The 9903 plugs into receptacles on the printed circuit card of the Ringdown module to provide a nominal 2-second-on/4-second-off cycle. The 9903 accommodates ring trip during either the silent or the ringing interval.

1.06 Signaling range of either 6003 or 6004 2Wire Automatic Ringdown module is 3000 ohms maximum loop length at −48Vdc operation, or 1500 ohms at −24Vdc.

Explanation

In this case, the Practice tells you, in pretty straight-forward language, that the 6003 & 6004 are used in 2 Wire circuits, that they perform all normal signaling and battery feed functions themselves, and that they can be used in either Loop Start or Ground Start applications.

Illustration: Applications Section

2. **application**

2.01 The 6003 and 6004 2Wire Automatic Ringdown modules may be applied to 2wire, metallic facilities to provide bi-directional automatic ringdown service. The 6003 is employed on metallic facilities connecting two stations or two trunks (figure 2).

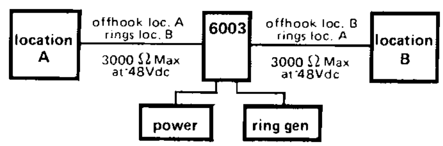


figure 2. 6003 interconnects two lines or trunks

The 6004, by virtue of its externally controlled transfer relay, may be used to interconnect three stations over metallic facilities in an arrangement whereby Station A has ringdown service with either station B1 or station B2. See figure 3. The 6004

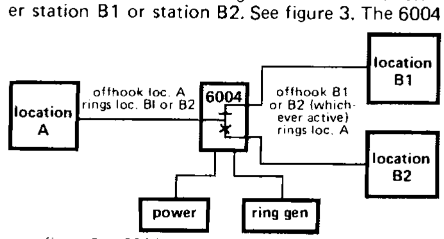


figure 3. 6004 interconnects three lines or trunks

is commonly applied to a ground start PBX ringdown circuit with an alternate connection for night service. In night service applications, the (loop start) night answer station is allowed one-way terminating service only, unless a ground start key is provided.

2.02 Switch options provided on both modules accommodate either loop start or ground start operation. The loop start mode is normally employed on lines, while the ground start mode normally finds application on trunks. Two separate and independent loop start/ground start switches allow line A on one side of the 6003 or 6004 to be optioned independently from line B on the other side of the module. A ground start trunk on one side of the module may, therefore, be interfaced for two-way ringdown service with a loop start line.

2.03 One-way ringdown service can be implemented through use of the loop start/ground start switches. If two lines employing loop start operation are interfaced by a 6003 or 6004, optioning one side of the module for the ground start mode will force the line on that side to a receive-only status. This mode of operation might typically be used on a ringdown circuit to a computer. To prevent the computer from originating a call when it (typically) opens the loop to release a call, then closes the loop again, the side of the 6003 or 6004 facing the computer is optioned for ground start. Optioned this way, the module will not recognize the computer's loop closure, nor will the circuit be seized by the computer.

Applications Section

Section 2 (Application) gives you more information, this time a little more specific, about how the Ringdown modules are used in the field. Here, the Practice shows you that the 6003 can ring a single station, whereas the 6004 can handle two. Either side of the circuit may be optioned for LS or GS; however, a GS option facing a computer prevents recognition of computer loop closure or computer seizure.

Installation Section

Section 3 of your Practice is the one you'll be most familiar with. This is the section which tells you exactly what to do to install and align your module. And there are essentially three parts to this section which you'll be concerned with.

- Connections
- Optioning
- Alignment

Illustration: Connections/Wiring Line Amps

installer connections

3.03 Before making any connections to the mounting shelf, ensure that power is **off** and modules are **removed**. The 4001A module should be put into place only **after** it is properly optioned and **after** wiring is completed.

3.04 Table 1 lists external connections to the 4001A module. All connections are made via wire wrapping at the 56-pin connector at the rear of the module's mounting shelf position. Pin numbers are found on the body of the connector.

connect:	to pin:
AMP 1 IN TIP	55
AMP 1 IN RING	49
AMP 1 IN SIMPLEX	53 and 51
AMP 1 OUT TIP	41
AMP 1 OUT RING	47
AMP 1 OUT SIMPLEX	43 and 45
AMP 2 IN TIP	7
AMP 2 IN RING	13
AMP 2 IN SIMPLEX	9 and 11
AMP 2 OUT TIP	5
AMP 2 OUT RING	15
AMP 2 OUT SIMPLEX	1 and 3
−BATT (−22 to −56Vdc filtered input)	35
GND (ground)	17

table 1. External connections to 4001A

Explanation: Connections/Wiring

All modules must be connected — via wire wrapping, Amphenol-type connectors, etc. — to the various conductors, leads, power and ringing sources, etc. which make the module work. These connections are specified in Section 3 of the Practice. The above illustration shows you such a connection specification. But before you do any wiring, be sure all power is turned OFF! In advance of any optioning, aligning or testing, you have to be sure that you've wired your module correctly to the various connections.

After you're wired up, it's a good idea to double-check the job. Once the wiring's correct, it's easy to install the module. All the connections are made at the rear of the mounting rack. So, when you're done, you only have to slide the module into its proper place. But before you do that, you'd better take care of setting the option switches.

Illustration: Optioning Line Amps

impedance	amp 1 in		amp 1 out		amp 2 in		amp 2 out	
	S1-2	S1-3	S1-4	S1-5	S4-3	S4-4	S4-1	S4-2
150 ohms	ON	ON	ON	ON	ON	ON	ON	ON
600 ohms	OFF	ON	OFF	ON	ON	OFF	ON	OFF
1200 ohms	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

table 2. Impedance optioning

gain range	amp 1	amp 2
	S1-1	S4-5
high (−2 to +35dB)	OFF	OFF
low (−15 to +6dB)	ON	ON

table 3. Gain range optioning

options
3.05 Four switch options, two of which are five-position DIP switches, must be set before the 4001A can be placed into service. Locations of these switches on the module's printed circuit board are shown in figure 8.

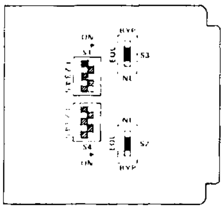


figure 8. 4001A option locations

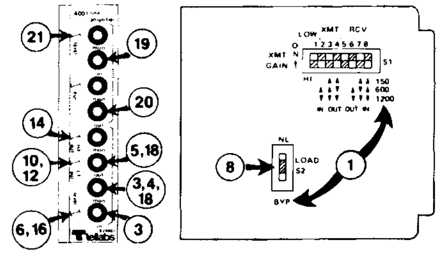
Explanation: Optioning

Practice Section 3 also includes an illustration showing the locations of the module's option switches — an example is shown above. The Practice's text will walk you through each option, even though most of the settings are written right on the circuit board itself. The Practice doesn't always describe each switch in numerical order, but rather it usually takes them in logical order of how you'd set them during an installation.

Metering

Sometimes, test-set measurements are required before you set all the option switches correctly. Remember the case of the hybrid's balance network where you must match impedances perfectly, or the Term Set's NBO capacitors which compensate for facility capacitance. In these cases you'll need to fine tune your own estimates using VOMs or other appropriate equipment. These requirements will be spelled out for you in this part of the Practice.

Illustration: Condensed Alignment



This condensed alignment procedure is provided to facilitate alignment of the 4001. After all option switches are set, adjust all front-panel controls fully counterclockwise, insert the 4001 into its mounting, apply power and perform each step in numeric order. This procedure details receive-channel equalization for loaded cable only. Refer to paragraphs 3.07 through 3.10 for information on equalizing nonloaded cable or carrier, or for further information on loaded cable equalization.

Receive Level Adjustment

1 **Option switches set correctly.** Verify optioning of the module (see paragraphs 3.05 and 3.06). Switch *S2* must be set to the *BYP* position.

2 **Front-panel controls fully counterclockwise.** Verify that all front-panel controls are adjusted fully counterclockwise.

3 **Connect test set to *rcv in mon* jack and opening plug to *rcv in* jack.** Use a properly terminated TMS arranged for receive.

4 **Have distant end send 1000Hz and verify.** Request that personnel at the serving central office send 1000Hz tone at the CLR-specified level. Verify the received level at the 4001.

5 **Remove opening plug and connect test set to *rcv out* jack.** Use a properly terminated TMS arranged for receive.

6 **Have 1000Hz sent and adjust *rcv level* control.** Request that personnel at the serving central office again send 1000Hz tone at the CLR-specified level. Adjust the *rcv level* control clockwise until the required level is achieved.

7 **Complete a frequency run. (If equalization is not required, proceed to transmit level adjustment.)** Perform a frequency run, measuring and recording levels at 300, 500, 1000, 2000, 2500, 3000, and 3400Hz, as appropriate. If the measured levels meet the conditioning requirements of the circuit, equalization is not required. Proceed to step 18 and perform the transmit-channel level adjustment. If equalization is required, proceed to step 8 and perform the loaded cable equalization procedure. If you are not using loaded cable, refer to paragraph 3.08 and perform the appropriate equalization procedure before proceeding to step 18.

Receive Equalization, Loaded Cable

8 **Reoption switch *S2*.** Set option switch *S2* to the *LOAD* position.

9 **Have 1000Hz sent.** Request that personnel at the serving central office send 1000Hz at the CLR-specified level. Record the 1000Hz level at the 4001.

10 **Have 300Hz sent and adjust to match 1000Hz level.** Request that personnel at the serving central office send 300Hz tone at the CLR-specified level. Adjust the *rcv LF eql* control clockwise until the 300Hz level is equal to the 1000Hz level.

11 **Have 1000Hz sent again.** Record the 1000Hz level.

12 **Have 300Hz sent and adjust to match 1000Hz level.** Have the serving central office send 300Hz and again adjust the *rcv LF eql* control to match the most recently recorded 1000Hz level.

13 **Have 1000Hz sent again.** The 1000Hz level should match the 300Hz level. If not, repeat steps 11 and 12 until these levels match.

14 **Have 3000Hz sent and adjust to match 1000Hz level.** Have 3000Hz sent and adjust the *rcv HF eql* control until the level at 3000Hz matches the last recorded 1000Hz level.

15 **Check levels at 300, 1000, and 3000Hz.** Check to verify that levels at 300, 1000, and 3000Hz are within conditioning requirements.

16 **Have 1000Hz sent and readjust *rcv level* control.** Request that personnel in the serving central office send 1000Hz tone and readjust the *rcv level* control as necessary to account for any loss introduced through equalization.

17 **Complete a frequency run, if necessary.** Perform a frequency run, measuring and recording levels at 300, 500, 1000, 2000, 2500, 3000, and 3400Hz, as appropriate.

Transmit Level Adjustment

18 **Remove all cords.** Remove all test cords before beginning transmit level alignment.

19 **Connect test set to *xmt in* jack and send 1000Hz at the CLR-specified level.** Connect a properly terminated TMS to the *xmt in* jack and insert 1000Hz test tone.

20 **Read transmit level at *xmt out* jack.** Connect a properly terminated TMS to the *xmt out* jack and read the transmit level.

21 **Adjust *xmt level* control.** Adjust the *xmt level* control clockwise until the level specified on the CLR is met.

Explanation: Alignment

Many Tellabs Practices include two different forms of Alignment Sections. The Long Form Alignment (not shown) tells you in detailed, paragraph-by-paragraph form, the steps to follow in order to align your module. These paragraph directions usually tell you everything, in detail, that's required for a perfect installation.

Sometimes Tellabs Practices also contain a Short Form or Condensed Alignment (shown above) which provides a brief, step-by-step outline for both optioning and aligning the module. The Short Form is a helpful overview and easy to follow, but if you run into a problem with it, be sure to refer to the lengthier, regular Alignment section for a more detailed explanation.

Note

Although the steps for installing a product are definitively laid out in the Practice, you may have some problem implementing these directions from time to time. Some procedures sound easy in the Practice, but are a little trickier in the field. Amplitude equalization is such a procedure. No matter how many times you read the directions for equalization, it's going to take you several hands-on installations before you'll become completely adept at it. In these cases, don't blame the Practice. A little hands-on experience goes a long way.

Exercise 1

1. In the following Practice Table of Contents, fill in the missing sections in their correct locations:

Contents

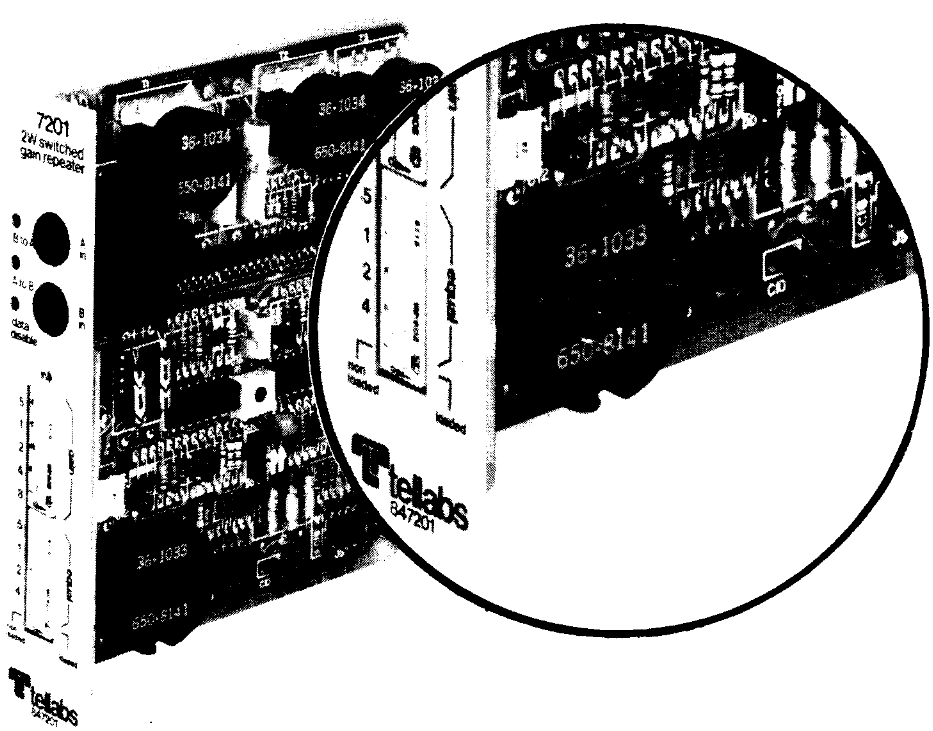
section 1	general description
section 2	application
section 3	____________
section 4	circuit description
section 5	____________
section 6	specifications
section 7	____________

2. The module issue level of this Repeater is ________.

3. Therefore, to install this module, you would need Practice section ________.

4. This module's manufacture date code is ________.

5. Therefore, its warranty period is valid until ________.



Exercise 2

Read a sample General Description from a Tellabs Practice and state three major features of the product described.

1. general description

1.01 Tellabs' 4201 and 4203 Terminating Sets (figure 1) provide toll-grade interfacing between 2wire and 4wire voice-frequency transmission facilities. Both modules feature switchable 600 or 900-ohm impedance termination on the 2wire side, while 4wire impedance terminations are fixed at 600 ohms. In each case, the resistive 600 or 900-ohm component of the impedance at a particular port is in series with a 2.15μF capacitive component.

1.02 This practice section has been rewritten to coordinate with the Videotape Training Program on Tellabs 4201 and 4203 Terminating Sets.

1.03 The 4201 is the basic 600/900-ohm Term Set. The 4203 adds an A-and-B-lead isolation coil (inductor) and an optional filter capacitor to the basic Term Set circuitry.

1.04 Fixed-impedance variable attenuators (adjustable T-pads) are provided at both the 4wire transmit and 4wire receive ports for level coordination. An attenuation range of approximately 0 to 30dB is provided in each direction. The variable attenuators are accessible from the module's front panel to allow level adjustments with the module inserted in its mounting shelf.

1.05 An internal compromise balance network in the 4201 and 4203 modules provides 600 or 900-ohm impedance in series with 2.15μF capacitance. A switch option removes the internal compromise balance network when use of an external precision balance network (PBN) is preferred. For Issue 2 or later 4201 Term Sets, this external PBN can be a Tellabs 993X PBN subassembly, which plugs into a receptacle on the module's printed circuit board. On Issue 1 4201 Term Sets and all issues of 4203 Term Sets, a Tellabs 423X PBN module may be used, as no provision is made for the 993X subassembly on these modules.

1.06 Network build-out (NBO) capacitors associated with the balance network provide NBO capacitance from 0 to 0.155μF in 0.005μF increments. These NBO capacitors can be used in conjunction with the internal compromise network or with an external or plug-on PBN.

1.07 All options are selected via slide switches or DIP switches. These options are selection of 600 or 900-ohm 2wire impedance; insertion or removal of the 4203's A-and-B-lead filter capacitor; removal of the internal compromise balance network for use with an external PBN; selection of NBO capacitance values; and selection of D-lead operation in the 4201 module.

1.08 In addition to the aforementioned transmit and receive attenuator controls, the front panel of each module contains a complement of four test jacks to facilitate alignment and maintenance. An opening jack faces the facility at the module's 4wire receive port. Opening jacks also face the module's 4wire transmit port and the module's 2wire port. The fourth jack is a bridging (monitor) jack at the 2wire port.

1.09 As Type 10 modules, the 4201 and 4203 each mount in one position of a Tellabs Type 10 Mounting Shelf, versions of which are available for relay rack and KTU apparatus case installation. In relay rack applications, up to 12 modules may be mounted across a 19-inch rack, and up to 14 modules may be mounted across a 23-inch rack. In either case, 6 inches of vertical rack space is used.

1. This is a general description of a ____________________ module.
2. The following are three major features of the module:
   A. ______________________________
   B. ______________________________
   C. ______________________________

Exercise 3

1. Where in the Tellabs Practice are pin connections listed?

   ____

Exercise 4

When given a sample circuit layout and option selections from a Tellabs Practice, correctly specify all internal option switches for that module.

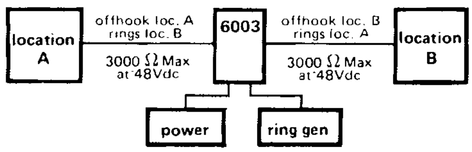
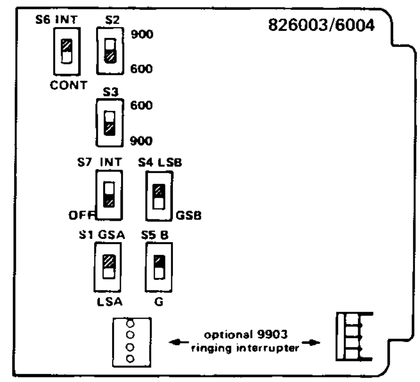


figure 2. 6003 interconnects two lines or trunks



Non loaded cable at both locations. Both locations are Ground Start. Continuous external Battery-biased Ring source will use internal Ring interruption through 9903 sub-assembly.

options and alignment

3.05 Neither the 6003 nor the 6004 module requires alignment. Before either module is placed into service, however, seven option switches must be set and the 9903 Ringing Interrupter subassembly, if used, must be plugged into its receptacles on the module. Locations of these option switches and receptacles on the printed circuit boards of the 6003 and 6004 are shown in figure 4. Optioning instructions are provided in paragraphs 3.06 through 3.10.

3.06 Switch S2 selects either 600 or 900-ohm terminating impedance on the line-A side of the module, and switch S3 selects either 600 or 900-ohm terminating impedance on the line-B side. Set S2 to the 600 or 900 position, as appropriate; then do the same with switch S3.

Note: If either side of the 6003 or 6004 is connected to a gain device, that side must be optioned to match the impedance of the gain device.

3.07 Switch S1 selects either loop-start or ground-start operation for line A, and switch S4 selects either loop-start or ground-start operation for line B. (Loop-start or ground-start operation can be selected independently for each line.) If line A is loop start, set S1 to LS; if line A is ground start, set S1 to GS. Similarly, if line B is loop start, set S4 to LS; if line B is ground start, set S4 to GS.

3.08 Switch S6 conditions the module for use with either continuous or interrupted external ringing generator. If the ringing generator is continuous, set S6 to CONT; if the ringing generator is interrupted, set S6 to INT.

3.09 In applications where external ringing generator is continuous but interrupted ringing is desired, switch S7 conditions the module for use with the optional 9903 Ringing Interrupter subassembly. If the 9903 is to be used, set S7 to INT and plug the 9903 into its two 4-pin receptacles on the module's printed circuit board. (Also ensure that S6 is set to CONT.) If the 9903 is not used, set S7 to OFF. See note 2 following paragraph 3.10 for special information regarding optioning when a tel set equipped with a buzzer rather than a standard ringer is used.

3.10 Battery-biased or ground-biased ringing is selected via switch S5. If battery-biased ringing is desired, i.e., if ring-generator bias is to be determined by the difference in dc potential between the RING GEN lead (pin 45) and the RING GEN RETURN (or RING GEN BIAS) lead (pin 11), set S5 to the G position. (In this case, the bias potential can be either 24 or 48Vdc.) If ground-biased ringing is desired, i.e., if ring-generator bias is to be determined by the difference in potential between the RING GEN lead (pin 45) and the GND lead (pin 17), set S5 to the B position.

Note 1: With ground-start operation, restrictions may apply regarding polarity of ring-generator bias. See paragraph 2.07 for these restrictions and paragraph 2.06 for ring-trip limitations.

Note 2: When a buzzer (rather than a standard ringer) is to be used in an associated tel set, the RING GEN lead (pin 45) must be connected to the input BATT lead (pin 35), switch S5 must be set to the B position, and switch S6 must be set to CONT.

Given this information, select the correct switch positions for the following switches:

S1 ____

S2 ____

S3 ____

S4 ____

S5 ____

S6 ____

S7 ____

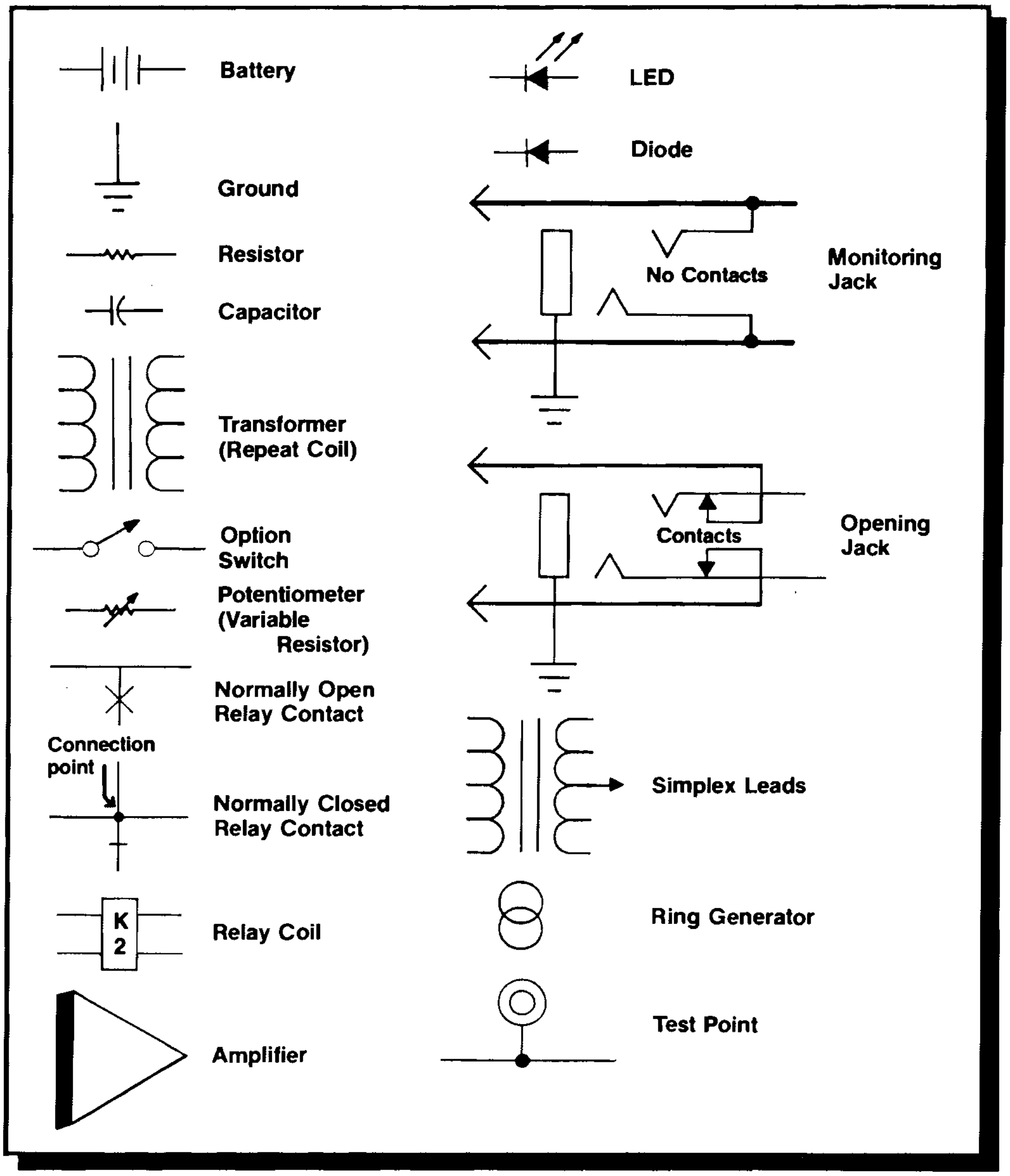
Circuit Description

The Circuit Description, Section 4, provides detailed engineering information about the functioning of the module. It explains how the module works and what the various electronic components do. This section doesn't really address any major installation concerns, but if you're especially interested in how a module works, the Circuit Description provides the information.

Block Diagram

Section 5, the Block Diagram, is critically important to understanding what you're installing. Like a road map, this single piece of information shows you, in usable detail, exactly what the module's circuitry looks like. A block diagram is less complex than a schematic and a whole lot easier to read. But like a map, in order to read a Block Diagram, you have to know some of the symbols and what they represent. Throughout this training program, we've shown you many of these Block Diagram symbols. Let's review.

Illustration: Block Diagram Symbols



Testing and Troubleshooting

Section 7 of your Tellabs Practice provides a checklist for testing your module after it's installed. On any installation, it's only necessary to test the operation of the module in the circuit. Don't try to test the module's internal components, because any such tampering may void your warranty. But by conducting the tests indicated in the Practice, you'll ensure that the module you installed is working properly.

Illustration: Testing Checklist for Line Amps

testing guide checklist

Note: *Because the two circuits (amp 1 and amp 2) of the 4001A are identical, this checklist applies to each circuit.*

test	test procedure	normal result	if normal conditions are not met, verify:
higher gain range	Ensure that circuit being tested (amp 1 or amp 2) is optioned for higher gain range (see table 3) and *BYP* (no equalization) mode. Arrange xmt portion of transmission measuring set (TMS) for 1000Hz tone output at −20dBm and at input impedance selected on module. Connect this signal to *amp X in* jack. Arrange rcv portion of TMS for terminated measurement at output impedance selected on module, and connect it to *amp X out* jack. Adjust *amp X level* control over its entire range.	With *amp X level* control fully counterclockwise (CCW), output level approx. 2dB lower than input level ☐. With *amp X level* control fully clockwise (CW), output level approx. 35dB higher than input level ☐.	Power ☐. Wiring ☐. Proper impedance terminations (check for double terminations) ☐. Impedance option switches properly set ☐. Equalizer option switch set to *BYP* ☐. Gain range option switch properly set ☐. Output level not exceeding +17dBm overload point ☐. Replace module and retest ☐.
lower gain range	Ensure that circuit being tested (amp 1 or amp 2) is optioned for lower gain range (see table 3) and *BYP* (no equalization) mode. Maintain TMS connections as described above, but change TMS output level to −10dBm. Adjust *amp X level* control over its entire range.	With *amp X level* control fully CCW, output level approx. 15dB lower than input level ☐. With *amp X level* fully CW, output level approx. 6dB higher than input level ☐.	Same as above ☐.
equalization, *EQL* (high-low) mode	Set equalizer switch of circuit being tested (*S3* for amp 1, *S2* for amp 2) to *EQL* position. Reoption circuit being tested for higher gain range (see table 3)	With *amp X LF eql* and *HF eql* controls fully CCW, 1000Hz level approx. 3dB lower in *EQL* mode than in *BYP* mode ☐. As *LF eql* and *HF eql* controls are	Power ☐. Wiring ☐. Proper impedance terminations (check for double terminations) ☐. Slide *S3* or *S2* to alternate position and back to clean contacts ☐

Explanation: Testing Checklist

The Practice checklist does three things. It specifies a procedure for each test. It states the normal conditions for each test — the results you should be looking for. And finally, it suggests remedies if you should get some improper results.

If you do run into a problem during testing and have to track down its source, verify all the conditions listed in the righthand column of the checklist. These are the most common sources of difficulty. After you've checked all of these things, it may be that the module still doesn't work. In that case, try some generic troubleshooting before you decide that the module's defective.

Illustration: Generic Installation Troubleshooting

1. Check wiring, pin connections.
2. Check option switches.
3. Check input power, biasing.
4. Check facilities.
5. Check input and output levels.
6. Check equalization, if required.
7. Check noise if trouble is a noise problem.
8. Check signaling leads for correct states.
9. If steps 1 and 2 are OK and module fails one of the other steps, correct that step then realign the module.
10. If module won't realign, call your Engineering Dept. or a Tellabs Customer Service Engineer.
11. If that doesn't help, replace the module.

Explanation: Generic Troubleshooting

Not all manufacturers provide the detailed testing checklist that you'll find in the Tellabs Practices. Or sometimes, there may be another problem in a circuit that's not covered in the checklist. In those cases, it's a good idea to follow these steps to solve your problem. Most times you can fix things by:

- Checking your wiring.
- Checking the module's option switches.
- Checking input power and biasing.
- Checking the facility.

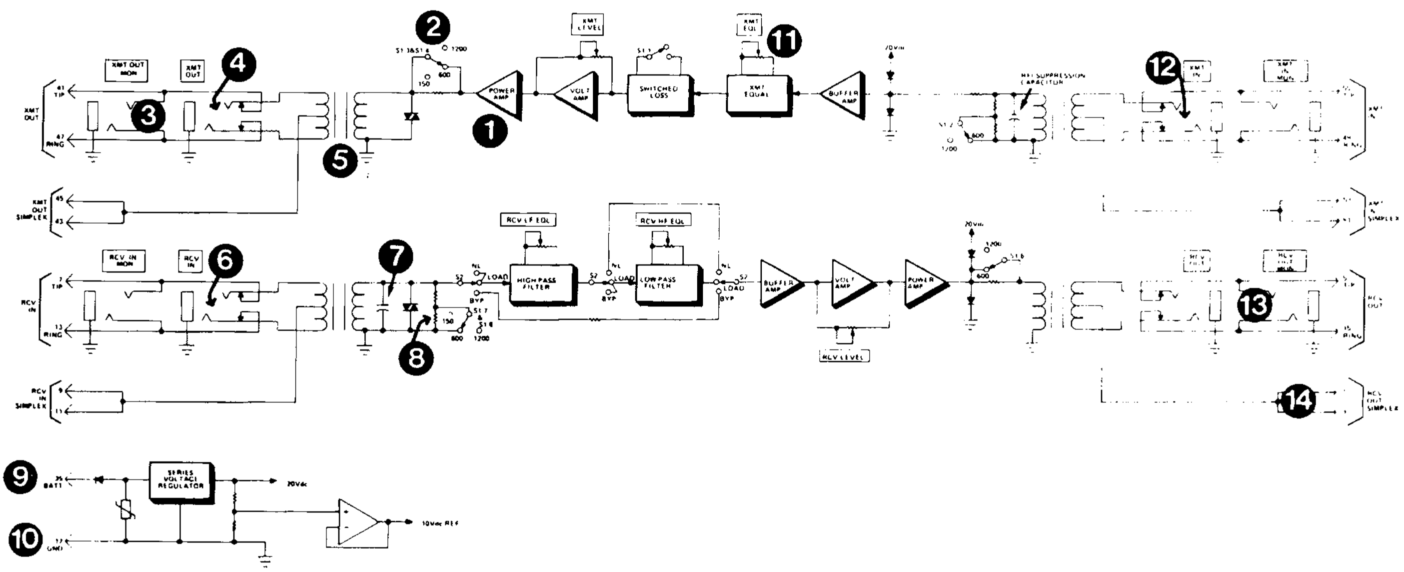
Remedial Action

After you've done these things, and you still have a problem, you may have to call the manufacturer. Tellabs provides comprehensive customer service. And our Customer Service Engineers are on-call 24 hours a day. We will get back to you to help.

Tellabs Number

If you have a real problem while installing one of our products, give us a call at (312) 969-8800, or call our closest Regional Office.

Exercise 5



In the space at left, place the number from the above diagram which corresponds to the component listed below.

_____ Amplifier

_____ Capacitor

_____ Battery

_____ Ground

_____ 4W XMT Input

_____ XMT Output Monitor

_____ Potentiometer (adjustable)

_____ RCV Output Monitor

_____ Switch

_____ Transformer

_____ 4W XMT Output

_____ 4W RCV Input

_____ Simplex leads

_____ Resistor

Exercise 6

testing guide checklist

test	test procedure	normal conditions	if normal conditions are not met, verify;
gain, A to B	Arrange xmt portion of transmission measuring set (TMS) to output 1000Hz tone at −10dBm, and connect this signal to *A in* jack. Arrange rcv portion of TMS for 900-ohm terminated measurement and connect it to *B in* jack.	*A to B* LED lights ☐. Signal level corresponds to gain settings ☐.	Power ☐. Wiring ☐. Gain settings ☐. Replace 7201 and retest ☐.
gain, B to A	Arrange xmt portion of transmission measuring set (TMS) to output 1000Hz tone at −10dBm, and connect this signal to *B in* jack. Arrange rcv portion of TMS for 900-ohm terminated measurement and connect it to *A in* jack.	*B to A* LED lights ☐. Signal level corresponds to gain settings ☐.	Power ☐. Wiring ☐. Gain settings ☐. Replace 7201 and retest ☐.
data disable	Set option switch *S1-1 (DD)* to *OFF*. Arrange xmt portion of TMS for 2100Hz tone output at −40dBm, and connect this signal to A in jack. Arrange rcv portion of TMS for 900-ohm terminated measurement and connect it to B in jack. Slowly increase 2100Hz level until *data disable* LED lights.	TMS indicates −30 ±3dBm ☐.	Switch *S1-1* set to *OFF* ☐. Power ☐. Wiring ☐. Replace 7201 and retest ☐.
data disable inhibit	Set option switch *S1-1 (DD)* to *ON*. Apply 2100Hz tone as directed in preceding step.	*Data disable* LED remains unlighted ☐.	Switch *S1-1* set to *ON* ☐.

After installing a Switched-Gain Repeater and performing the tests listed above, you have obtained the results listed below. In the spaces at right, indicate possible solutions to these problems:

1. A-to-B signal level does not correspond to gain settings. ______________________

   ____

2. B-to-A LED does not light. ______________________

   ____

Exercise 7

In the spaces at left, place an "X" beside the first four steps to be followed when checking any Tellabs product for installation troubleshooting. Place a "Z" beside the last two steps to be taken.

_____ Check wiring and pin connections.

_____ Check equalization (if required).

_____ Check signaling leads.

_____ Replace module.

_____ Check noise (if relevant).

_____ Call Customer Service Engineering.

_____ Check input power and biasing.

_____ Check input and output levels.

_____ Check option switches.

_____ Realign the module (if necessary).

_____ Check facility.

A

A&B Leads — 2 Wire Signaling leads derived from Tip and Ring.

Alternating Current (AC) — Electrical current which changes directions periodically, travels in waves, and is used to transmit voice.

Amperes — Measurement of electrical current (amount of electron flow).

Amplifier — Gain device; makes output power greater than input power.

Attenuator — Loss device; makes output power less than input power.

Augmented SF — Initial burst of higher level SF tone to aid in signaling detection.

Automatic Ringdown — Dedicated circuit which allows one phone's off-hook to ring another phone (no dialing required).

B

Balance Network — Adjustable circuit elements which allow for impedance and capacitance matching.

Battery (grounded) — DC generator, connected to ground, normally supplying -24V or -48V DC.

Battery-Biased Ring Generator — Ring Generator connected to DC battery (Tip side to Ground).

Bi-Directional Transmission — Concurrent transmission of Transmit and Receive information.

C

Cable Pair — Twisted conductors, in telephony, called Tip and Ring.

Capacitor — Electrical component which blocks DC but allows AC to pass; it stores electrical energy.

Capacitive Balance Network — Adjustable circuit components which compensate for capacitance in DX circuits.

Carrier (CXR) — High frequency circuit (often microwave) which allows for bulk transmission via cable or radio.

Central Office (C.O.) — Telco location where switching of phone calls is done.

Condenser Microphone (Transmitter) — Part of telephone which converts sound energy to electrical energy.

Conductor — Facility which carries electrical energy.

Current — Actual flow of electrons (measured in amperes) passing through a conductor.

Cut-and-Terminate (CT) Relay — Relay in SF Transceiver which, when SF tone is detected, cuts and terminates the circuit.

D

Decibels (dB) — Relative unit of power (amplitude) of sound.

dBm — Unit of power measured against a standard (1 milliwatt across 600Ω).

dBm0 — Unit of power which remains constant relative to another fluctuating level.

Dial Long Line — Special Service device which extends loop signaling distance.

Direct Current (DC) — Electrical current which travels in one direction only.

DC Detector — Ring Trip circuitry which stops Ring Generator when called phone goes off-hook.

DC Isolation — Operation of hybrid or transformer which interrupts DC flow.

DTMF — Dual Tone Multi-Frequency: Push button dialing. Use two tones out of eight for signaling on a line.

Doubletalk — Simultaneous bi-directional speech on a circuit.

Duplex (DX) Signaling — Extended E&M signaling in both directions using DC.

DX1 — DX configuration with M-lead inputs and E-lead outputs.

DX2 — DX configuration with E-lead inputs and M-lead outputs.

DX Reference Lead — Part of DX unit which remains constant at approximately -20V and compensates for differences in ground potential.

DX Signaling Lead — Part of the DX unit which varies between -5V and -48V, depending on on-hook and off-hook conditions.

E

E&M Leads — Standardized signaling leads for use with switches and signaling sets. In normal configurations: E = RCV, M = XMT.

E Lead States — (Normally) Idle = Open, Busy = Ground.

Echo Return Loss — Measurement of 2 Wire impedance as reflected energy; the difference between transmitted and reflected voiceband energy.

Equalization — The reduction of attenuation distortion across a given bandwidth connection of an altered frequency response.

F

Facility — Metallic or non-metallic transmission medium connecting parts of a telephone network.

Facility Unbalance — Transmission problem resulting from the accidental grounding of one of a cable pair.

Foreign Exchange (FX) — A circuit in which dial tone originates at a distant C.O.

FXO — The office or switch side of a Foreign Exchange circuit.

FXS — The station or telset side of a Foreign Exchange circuit.

4 Wire Circuits — Circuits using separate cable pairs for Transmit and Receive.

Frequency — The rate of generation of AC current waves, sound waves, etc., as measured in Hz.

Frequency Response — A comparison of frequency (pitch) vs. level (power) across a given bandwidth.

G

Ground — A conducting connection to earth potential (0V).

Grounded Ring Generator — Ring Generator connected to Ground (Tip side to battery).

Ground Start Supervision — Trunk circuitry developed to prevent head-ons or glare.

H

Hertz (Hz) — Measurement of frequency (cycles per second).

Hybrid — Transformer network used to interface 2 Wire and 4 Wire circuits.

Hybrid Repeater — 2 Wire Repeater which uses a hybrid to separate XMT and RCV paths.

I

Impedance — Total AC resistance and reactance.

Impedance Matching — Compensation for a facility's impedance in order to increase return loss.

In-Band Signaling — Inclusion of a specific tone within the voice bandwidth to indicate on-hook or off-hook phone states.

Inductance — Electrical characteristic which causes opposite and equal AC currents to flow on both sides of a transformer.

Inter-office Trunks — Shared facilities connecting C.O. switches.

L

LED — Light-emitting diode.

Level — Circuit power or volume as measured in dB.

Line Amplifier — 4 Wire device which adds gain or loss in both XMT and RCV directions.

Line Relay — Central Office relay which senses telephone off-hook state and allows DC current flow in station loop.

Load Coil — Donut-shaped core wound with copper wire used to increase distributed inductance of a cable pair.

Loaded Cable — Cable with load coils inserted at periodic distances.

Local C.O. (Class 5) — Central Office (end office) capable of switching calls between local circuits.

Loop Current — DC current (-24V or -48V), present during off-hook, which powers the telephone.

Loop Extender — Floating power source located in the C.O. which increases signaling range of a circuit.

Loop Sense — Relay which senses off-hook and allows current to flow (see Line Relay).

Loop Start Supervision — Normal loop circuit which immediately causes current to flow when phone goes off-hook or when trunk is accessed.

M

M Lead States — (Normally) Idle = Ground, Busy = Battery.

Minimum Station Current — 23mA for rotary-dial phones, 30mA for DTMF, required to power phones.

Monitoring Jack — Connecting device to which circuit wires are attached. Insert plug is used to monitor facility.

Multi-Frequency (MF) Signaling — In-band trunk signaling, using two tones out of six, which pass information between C.O.s.

N

NBOC — Network Build Out Capacitance: Compensates for capacitance found in cable pair; part of Term Set.

Negative-Impedance Repeater — 2 Wire Repeater which electronically cancels out AC Resistance.

Network Termination — A circuit's demarcation point between Telco and end user.

Non Loaded Cable — Cable pair with no load coils; typically 600Ω impedance.

O

Off-Hook — A busy telephone, one in which loop current flows from the switch.

Off-Premises Station (OPS) — A telset extension from a PBX; located at some distance from the PBX.

Ohm (Ω) — Unit of DC resistance or AC impedance; used in telephony to indicate distance.

On-Hook — An idle telephone, one which does not draw loop current.

Opening Jack — Female connecting device to which circuit wires are attached. Insert plug opens circuit; allows for monitoring the module.

Optioning — Setting of module switches for circuit parameters: impedance matching, balance networks, etc.

P

Pad — Attenuator.

Post-Equalization — The reduction of attenuation distortion (i.e., correction of frequency response) after that distortion has already occurred.

Potential — Voltage; the equivalent of electrical pressure; the capability of pushing current through a conductor.

Potentiometer (POT) — Variable resistor; an adjustable control often on the front of a module.

Practice — Technical and installation manual.

Precision Balance Network — Device which allows for extremely accurate impedance and capacitance matching.

Pre-Equalization — The reduction of attenuation distortion (i.e., correction of frequency response) in advance of its occurrence as a preventive measure.

Private Branch Exchange (PBX) — A private switchboard usually in a business application, which connects numerous telsets with a lesser number of trunks.

PBX Line Circuit — The part of a PBX to which a station is connected.

PBX Tie Lines — Shared facilities (trunks) which connect PBXs to PBXs.

PBX Trunk Circuit — The part of a PBX connected to a trunk.

PBX Trunks — Shared facilities which connect PBXs to C.O.s.

Pulsing — A series of open and closed loop states which indicate dialing.

Pulse Correction — The respacing and reshaping of dial pulses to correct distortion.

R

Receive — Transmission function in which electrical energy is converted to sound energy.

Repeater — Transformer device used to increase power in a circuit.

Resistance — Opposition to electrical flow in a conductor; measured in Ohms (Ω).

Resistive Balance Network — Adjustable circuit components which compensate for resistance in DX circuits.

Ring — Cable pair conductor; normally connected to battery at the C.O.

Ringback Information — Dial tones, busy signals, and indications of ringing of distant phone.

Ringer — Bell or buzzer whose activation indicates an incoming call.

Ring Generator — Nominal 105V AC which supplies power to ring the phone.

Ringing Relay — Relay, located at Central Office, which allows Ring Generator to be applied to the called party.

Ring Trip — DC detection circuitry which stops ringing when called phone goes off-hook.

S

Signaling — Procedure which indicates to the receiving end of a circuit that intelligence is to be transmitted.

Signaling Converter — Device which converts one form of signaling into another (i.e., E&M to SF).

Simplex Leads — Parallel signaling paths derived from center-tapped connections to repeat coils across the circuit.

Single Frequency (SF) Signaling — The use of tone, 2600Hz, at -20dBm0, to denote on-hook, off-hook and pulsing states.

SF Transceiver — The part of the SF signaling set which transmits and receives the 2600Hz SF tone.

Supervision — Indication at the C.O. of the state of a particular circuit: on-hook, off-hook, pulsing, etc.

Switched-Gain Repeater — 2 Wire Repeater which adds gain to one direction of the circuit while providing an equal amount of loss in the other direction.

Switching — The connection of a calling party to the called party.

T

Talk Battery — DC power supply, usually -24V or -48V, which powers the telephone.

Talk-Off — Accidental duplication of SF tone which disconnects a call.

Term Set — Hybrid device which converts a 2 Wire circuit to 4 Wire circuit or vice versa.

Tip — Cable pair conductor; usually connected to Ground at the C.O.

Transformer — Repeat coil or induction coil which causes opposite and equal AC current to be induced across a magnetic field.

Transhybrid Loss — Inevitable 4 ± .5dB loss inherent in all hybrid devices due to balance network.

Transmission — The transference of intelligible information (voice or data) from one point to another.

Transmission Level Point (TLP) — Specified alignment level usually +7dBm RCV and -16dBm XMT.

Transmitter — (See Condenser Microphone).

Trunks — Shared facilities between two switching devices.

U

Unstable Amplifier — Amplifier which exhibits echo, singing, or howling which could be due to mismatched impedances on XMT and RCV sides.

V

Voice Frequency (VF) Bandwidth — 300-3000Hz range in which 90% of all speech is included.

VF Repeater — Amplifier used to provide gain in voice quality circuits.

Voltage — Measurement of electrical potential (i.e., pressure) in a conductor.

VOM — Meter for measuring voltage, resistance and current.

W

Wire Gauges — Thickness of a given conductor; affects resistance and attenuation.

Wire Wrappings — Connections at rear of mounting board where module is connected.

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Generic Telephony Training

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Section 2: POTS — A Review of Terms and Concepts (cont'd.)

**Section 2:
POTS —
A Review of Terms
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Section 4: Repeaters and DLLs
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Section 5: Basic 4 Wire Transmission

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Section 2

Exercise 1

A. On-hook
Current does not flow
B. Off-hook
Current flows

Exercise 2

1. A. Current will flow
B. Current won't flow
2. C. Has most resistance

Exercise 3

1. A. 300Hz, 3dBm
B. 1000Hz, -3dBm
C. 3000Hz, -12dBm

2. 300Hz to 3000Hz

3.

3.	A. +7dBm		F.	+8dBm
	B. +23dBm		G.	+12dBm
	C. +41dBm		H.	+28dBm
	D. +17dBm		I.	+46dBm
	E. +14dB		J.	+22dBm

Exercise 4

6	15	4	9	
6	16		19	
	13		18	
	17	3	11	12
1	21	2	10	
7	20		14	
5	8			

Exercise 5

1. Transmission, Ring Generator
2. Signaling, powering the phone
3. Talk Battery
Power
Line Relay
Ringback Signals
Information Signals
Ring Generator
Switching

Exercise 6

1. B
A
2. A&B
A&B
3. Last two statements
4. 19, 22, 24, 26

Exercise 7

1. C. Power loss
B. Crosstalk
D. Induced noise
2. Opposite and equal current
AC
Inductance
3. 3
Blocks DC, allows AC to pass

Exercise 8

1. A. Grounded
B. Battery
2. A. Battery-biased
B. Ground
3. Battery

Exercise 9

1.		2.	
	L1		M1
	F2		Q2
	R3		F3
	D4		A4
	Q5		J5
	N6		J6
	M7		A7
	O8		B8
	S9		E9
	E10		C10
	H11		H11
	I12		K12
	K13		N13
	A14		B14
	C15		D15
	B16		G16
			O17

Section 3

Exercise 1

1. Loaded
2. Non loaded

Exercise 2

1. A
2. E
3. B
4. D

Exercise 3

1. D
2. B
3. F

Exercise 4

1. Extend loop signaling
2. At the C.O.
3. One per circuit

Section 4

Exercise 1

1. D. Up to 11 from the C.O.
2. A. Two DLLs on the same circuit.
   B. One DLL with external power supply.

Exercise 2

T
T
C
C
T
C
T
C
T

Exercise 3

1. 4
   6
   5
   8
   1, 2, 3
   1
   7
2. 3 3
   2 2
   4 1
   1 4
   5

Exercise 4

1. Up to 1300 from C.O.
2. A+ PBX
3. S1 BYP
   S2 600
   S3, 4 INTA, INTB
   S5 600
   S6 OFF
4. Reversed leads
   Switch leads

Exercise 5

H
Z
H
H
S
S

Section 5

Exercise 1

1
3
5
7

Exercise 2

1. B, D
2. C
3. B

Exercise 3

1. Level control F
2. Impedance matching D
3. Simplex leads C
4. Equalization G

Exercise 4

1. Center-tapped DC signaling leads
2. Separates signaling from transmission; allows signaling to be handled separately

Exercise 5

14	A	
8, 15	B	
9, 16	C	
10, 17	D	
11, 18	E	
1	F	
4	G	
5	H	
7	I	
12, 13	J	
19	K	
2	L	
3	M	
	N	Term Set
6	O	Dial Long Line

Exercise 6

1. 9dB XMT
   9dB RCV
2. 11dB XMT
   12dB RCV
3. 600
   600
   600
4. Loop start

Section 6

Exercise 1

2
4
5

Exercise 2

1. M lead is X.
   E lead is Y.
2. On-hook
   Off-hook
3. Input/receive
4. Output/transmit

Exercise 3

1. P
   Q
2. Idle
3. Ground
   Battery

Exercise 4

Type II
Type III
Type I

Exercise 5

1. No
2. Yes
3. Yes, tandem application

Exercise 6

1. S, A
   R, B
   S, C
   R, D
   Contacts
   Distant off-hook
2. S, A
   R, B
   S, C
   R, D
   Reverse/Normal

Exercise 7

1.	DX2, A	E&M, 1
	DX1 or DX2, B	SX, 2
	DX1 or DX2, C	SX, 3
	DX1, D	E&M, 4
		A + B, 5
		E&M, 6
2.	D	

Section 7

Exercise 1

1. AC, in-band, present during off-hook
2. 3, f
3. B

Exercise 2

4. A. Y
   B. Z
   C. W

Exercise 3

1. A. +7dBm
   B. -16dBm
   C. +7dBm
   D. -16dBm

Exercise 4

1. Accidental disconnect due to time, level, frequency
2. Frequency, duration of tone, -20dBm0
3. D

Exercise 5

1
2
3
12

Exercise 6

1.	On	Off
	Pulse A-B	Off
	On	On/Off
	B	A is OPS
2.	On	Off
	On	On
	Off	On
	On	On

Section 8

Exercise 1

1. installation
   block diagram
   testing & troubleshooting
2. 4
3. 847201
4. 26 Oct 81
5. 26 Oct 86

Exercise 2

1. Term Set
2. Fixed impedance, variable attenuator
   Internal compromise balance network
   NBOCs
   Switch options
   Test jacks

Exercise 3

1. Installation section (3), block diagram

Exercise 4

S1	GSA
S2	600
S3	600
S4	GSB
S5	G
S6	Cont
S7	Int

Exercise 5

1	13
7	2
9	5
10	4
12	6
3	14
11	8

Exercise 6

1. Power, wiring, gain settings
2. Power, wiring, gain settings

Exercise 7

X — Wiring, pins
Input power, biasing
Option switches
Facility

Z — Replace
Call Customer Service

tellabs

Training Validation

Thank you for participating in the initial validation of Tellabs new Generic Special Services Training. Although you may not be members of our ultimate target audience, *Special Services Installers*, we'd certainly appreciate any inputs which will help us to improve the program.

Name ____________________

Your telephone experience ____________________

Your previous telephony or electronics training ____________________

____

Please rank the entire training program by circling the appropriate number which you feel characterizes the whole presentation.

Course Organization	1 Random	to	5 Clearly Defined	1	2	3	4	5
Order of Presentation	1 Undifferentiated	to	5 Increasing Complexity	1	2	3	4	5
Difficulty	1 Overview	to	5 Comprehensive	1	2	3	4	5
Exercises	1 Simple	to	5 Rigorous	1	2	3	4	5
Objectives	1 Theoretical	to	5 Realistic/Task-Oriented	1	2	3	4	5
Textbook	1 Needed much note-taking	to	5 Easily Referenced	1	2	3	4	5
Illustrations	1 Required Study	to	5 Easy to Understand	1	2	3	4	5
Pacing	1 Needed more time/assistance	to	5 Digestible Chunks	1	2	3	4	5
Length	1 Needed more time	to	5 Accomplished objectives in time allotted	1	2	3	4	5

PERFORMANCE: I achieved correct answers approximately ____% of the time.

SUBJECTIVE COMMENTS: ____________________

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INDIVIDUAL SECTIONS: Categorize on the grid how you responded to each text section.
1 = never, 2 = sometimes, 3 = mostly, 4 = usually, 5 = always

	Enjoyed	Understood Basic Concepts	Achieved Objectives	Finished Exercises and Understood Solutions	Followed Class Discussion	Participated in Discussion	Needed More Time/Help
Transmission/Signaling Film							
POTS: Review of Terms							
Extended Circuits							
Repeaters & DLLs							
4 Wire Transmission							
E&M and DX Signaling							
SF Signaling							
How to Use a Practice							

Areas I'd like to study more: __________

Things I'd like to see expanded: __________

Things I'd like to see shortened: __________

Topics directly related to my job: __________

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