IBM Field Engineering Education
Student Self-Study Course

IBM Confidential

Common Carrier Facilities for Teleprocessing

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PREFACE

This course is provided to acquaint Customer Engineers with some of the important concepts of Common Carrier equipment and facilities as used in Teleprocessing environment. This course will also provide the Customer Engineer with a permanent reference for these facilities.

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SECTION 1

TELEGRAPH

SESSION 1

TELEGRAPH SYSTEMS

Upon completing this session, you should be able to explain the principles, functional units, and telegraphic circuits used within telegraph networks. You will also become familiar with distortion in telegraph circuits and how distortion is handled.

Highlights:

- Principles
  - Concepts
  - Speeds
- Transmission Methods
  - Wire
  - Radio Telegraph
- Functional Units
  - Polar Relays
    - 225A
    - IBM Mercury-Wetted
    - WU 202
  - Junction Boxes
    - 63C1, 2
    - IBM Line Terminator Box
    - Plugs
  - Line Arrestor Coils
  - Repeaters
    - Regenerative (mechanical)
    - Regenerative (electronic)
- Representative Type Equipment
  - R0 - Receive Only Page Printer
  - KSR - Keyboard Sending and Receiving Unit
  - ROTR - Receive Only Typing Reperforator
  - PERF - Perforator
  - KTR - Keyboard Typing Reperforator
  - TD - Transmitter Distributor
  - RT - Reperforator Transmitter
  - ASR - Automatic Sending and Receiving Unit
- Basic Telegraph Circuit
  - Circuit Tapes
  - Line Currents
  - Line Voltages
- Telegraph Signal Distortion

TELEGRAPH PRINCIPLES

Telegraph circuits have line speeds ranging from approximately 45 to 75 BPS, and normally are attached to terminals employing the asynchronous mode of transmission. The major difference between telegraph transmission and all other methods is the type of modulation used. Telegraph circuits rely on direct current modulation. Direct current modulation is particularly adaptable to low-speed, low-quality lines. The basic telegraph circuit consists of a dc power supply, send relay points, and a receive relay coil. Refer to Figure 1-1.

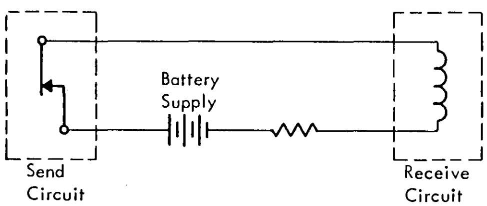


FIGURE 1-1. BASIC TELEGRAPH CIRCUIT

TRANSMISSION METHODS

There are two basic methods of telegraph transmission:

1. Straight wire
2. Radio telegraph

The first we will discuss is the straight wire method (Figure 1-2). In this case, the telegraphic data to be transmitted is converted to current - no current and is imposed on a two-wire network. This method is primarily used at the originating and terminating ends of long distance data links.

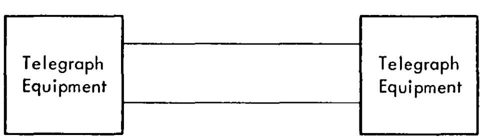


FIGURE 1-2. STRAIGHT WIRE TELEGRAPH LINE

The second and most versatile method of telegraphic transmission is through the incorporation of radio. This concept takes on many configurations, the first of which is radio telegraph FSK (Figure 1-3). This method employs a radio transmitter/receiver that is frequency-keyed by incoming telegraphic (current - no current) data. The receiving station detects the frequency shift and generates telegraphic (current - no current) output. Frequency shifts of 45 cps are common. A modification of this method is the introduction of a coaxial line instead of the radio link (Figure 1-4)

Radio telegraphic utilizing audio FSK (Figure 1-5) is yet another method in use today. This concept utilizes a fixed carrier radio transmitter and relies on audio modulation (AFSK). The incoming telegraphic data at the transmitter is converted to tones and is used to modulate the radio frequency carrier. The receiving station converts the incoming AFSK signal back to tones, and then to telegraphic (current - no current) data.

FUNCTIONAL UNITS

Polar Relays

The polar relay connects the terminal equipment and the telegraph line. There are three basic types of polar relays. The first, WE 225A (Figure 1-6), is manufactured by Western Electric and is used in the IBM 067 Transceiver. The 255A plugs into a special socket and is held in place by spring clips. The relay has two separate coils: the pick coil and a bias coil. The bias coil is normally energized with an adjustable dc voltage. The bias winding generates a magnetic field which either bucks or boosts the action of the pick coil. The effect of the bias coil allows the characteristic pick and drop time of the relay to be varied. Figure 1-7 is a diagrammatic representation of the polar relay.

The second basic type of polar relay is manufactured by IBM (Figure 1-8). It consists of a mercury-wetted reed relay and coil. The pick coil surrounds the glass reed capsule similarly to the standard IBM reed relay. The relay is available in two versions, the first being a send relay which has one coil. The receive relay has both pick and bias coils. The IBM polar relays are mounted on a SMS card. The complete SMS card must be replaced if any of the relays becomes defective.

Another type of polar relay is the WU 202A (Figure 1-9), also used in the IBM 067 Transceiver. The armature operates on a rocker principle. It pivots in the center allowing the contacts at the ends of the armature to open and close. The relay has both pick and bias windings.

DANGER

Be careful when working near polar relays. Other than normal voltages are present. Voltage of 130 vdc and greater are present.

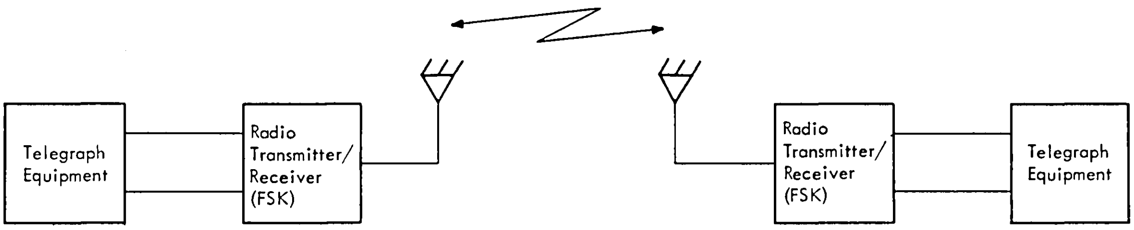


FIGURE 1-3. RADIO TELEGRAPH — FSK

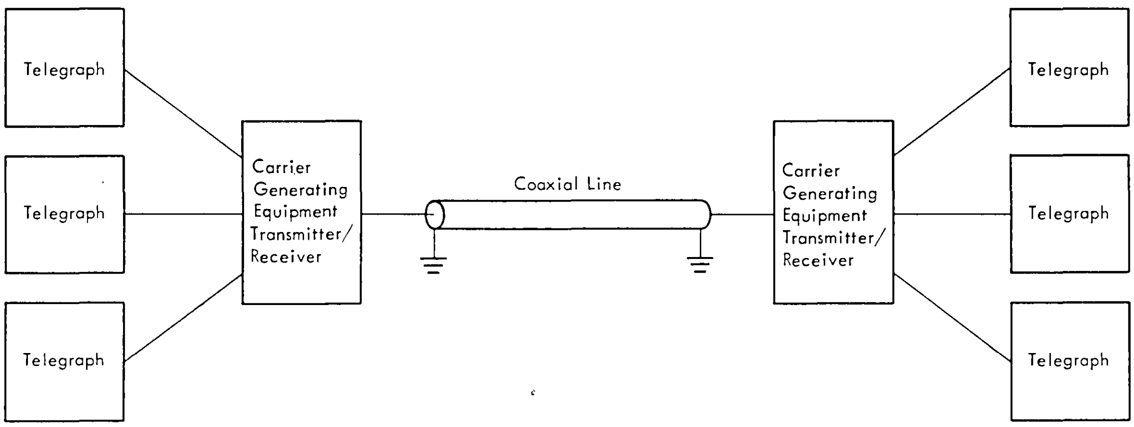


FIGURE 1-4. LINE CARRIER SYSTEM

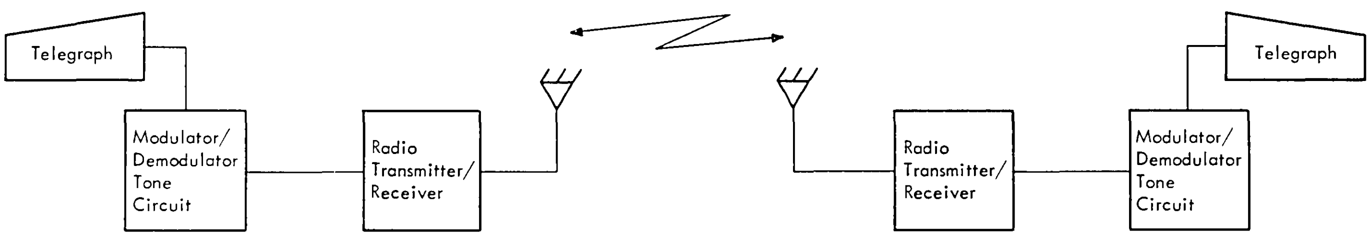


FIGURE 1-5. RADIO TELEGRAPH UTILIZING AUDIO FSK

Junction Boxes

Junction Box - 63C1, 2

Connection of terminal equipment to the telegraph lines is facilitated by an unusual array of plugs, cords, and switch boxes. The incoming telegraph lines are usually terminated in a centralized junction box. The WE 63C1, 2 telegraph loop switchboard (Figure 1-10) is one type of junction box. It is provided with a number of pluggable receptacles which facilitate distribution of input telegraph lines to one or more terminals. The individual receptacle (Figure 1-11) within the 63C1, 2 is provided with a built-in switch and resistor which terminates the telegraph line when a plug is not installed.

DANGER

Other than normal voltages will be found in and around the connections to the telegraph lines. Voltages between 130 vdc and 260 vdc are common.

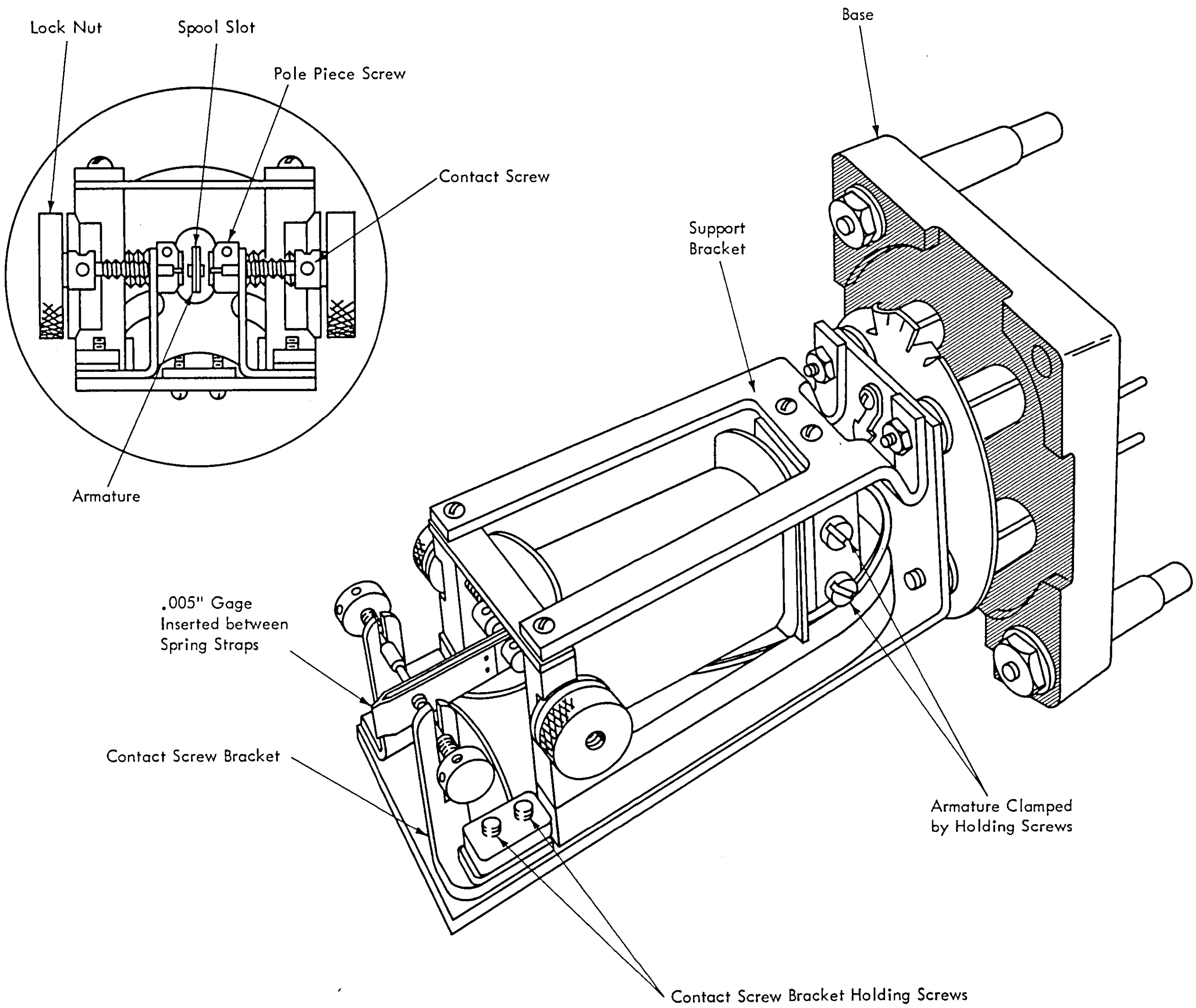


FIGURE 1-6. POLAR RELAY (WE 255A)

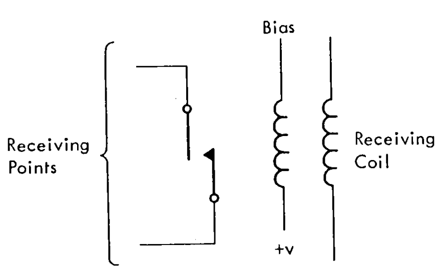


FIGURE 1-7. POLAR RELAY CIRCUIT

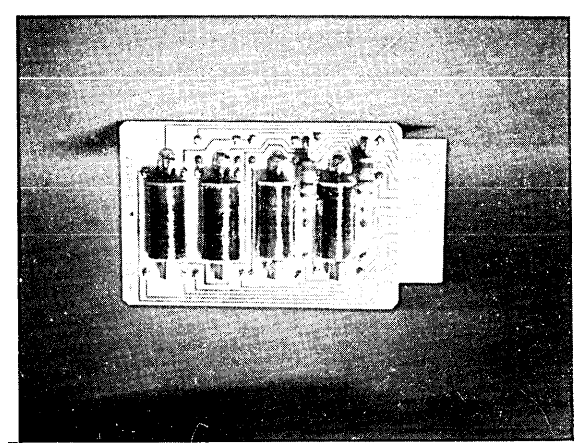
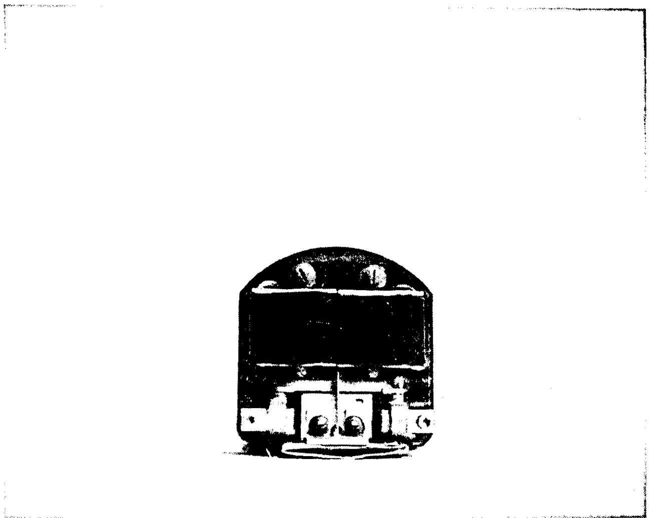


FIGURE 1-8. IBM MECURY-WETTED POLAR RELAY



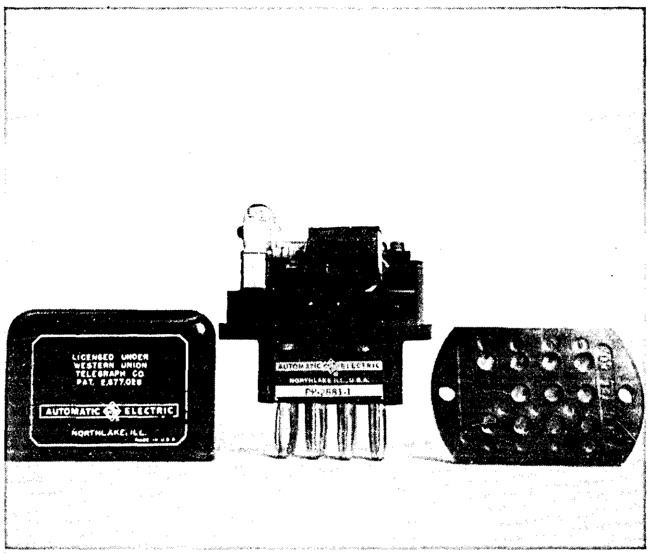


FIGURE 1-9. POLAR RELAY, WU 202A

Line Terminator Box

Another type of junction box available is the IBM line terminator box (Figure 1-12). This unit is provided by IBM and serves as the distribution point for telegraphic lines servicing one of more terminals.

Plugs

Various types of plugs and cords are used to connect terminal devices to the junction box. They vary depending upon the type of terminal devices and junction box. Figure 1-13 show two types of plug and cord that may be encountered.

Line Arrestor (Heat) Coils

Line arrestor (Figure 1-14) coils are provided by the common carrier. Their function is to protect the telegraphic circuit from overcurrent conditions. The arrestor coils are designed to open electrically when line currents exceed 265 ma. It is interesting to note that the polar relay usually is burned out long before the 265-ma limit is reached.

Repeaters

When telegraphic signals are transmitted over long distances, straight-wire distortion becomes an inherent problem. The transmitted signals lose their identity and must be reshaped as well as amplified.

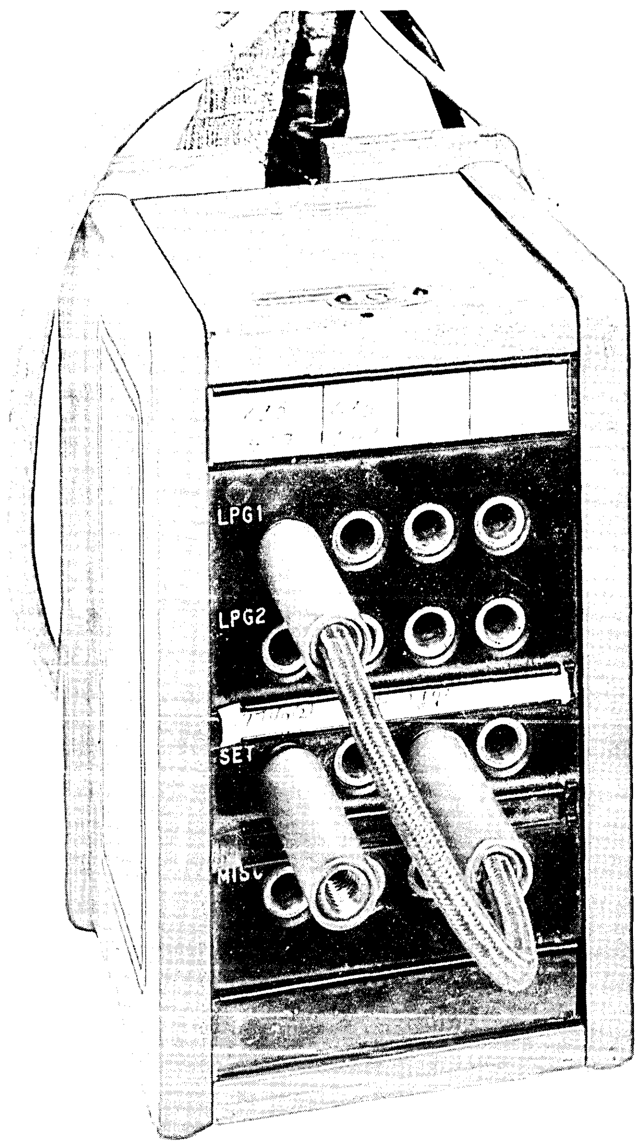


FIGURE 1-10. TELEGRAPH LOOP SWITCHBOARD, WE 63 C1, 2

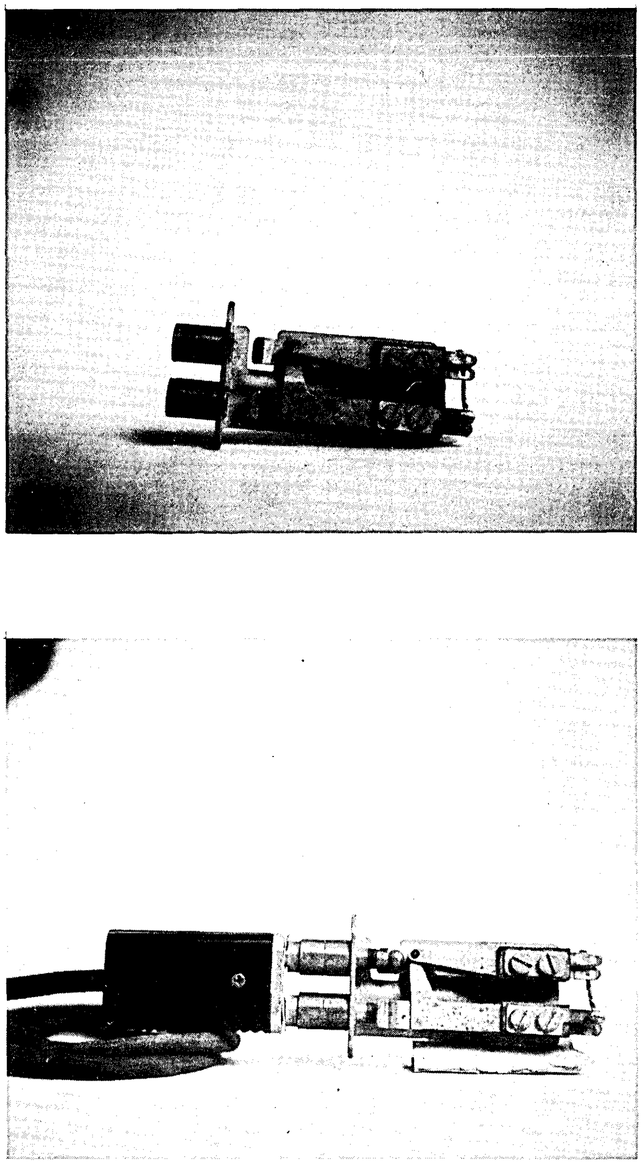


FIGURE 1-11. INDIVIDUAL TELEGRAPH JACK

The repeater provides this function. Figure 1-15 lists typical repeater spacings for various types of telegraph lines and speeds.

There are two types of repeaters; electromechanical and electronic. The electromechanical repeaters are code sensitive; that is, they are designed to repeat only one type of code, such as four of eight. The electronic repeaters are much more versatile and can regenerate many different code structures.

Mechanical Repeater

The mechanical repeater (Figure 1-16) consists of two emitters that are mechanically connected in parallel. The emitter wipers are held in a latched position until an incoming character is received by the repeater. When the start bit of the incoming character is received, the emitter wipers are unlatched and are allowed to scan their respective emitter segments in synchronism with the incoming telegraphic data. As the incoming character is sampled by the receive emitter wiper, bit relays corresponding to the bit structure of the character are energized. One bit time later, the bit relays are sampled by the transmit emitter wiper and are read out onto the output telegraph line. The output

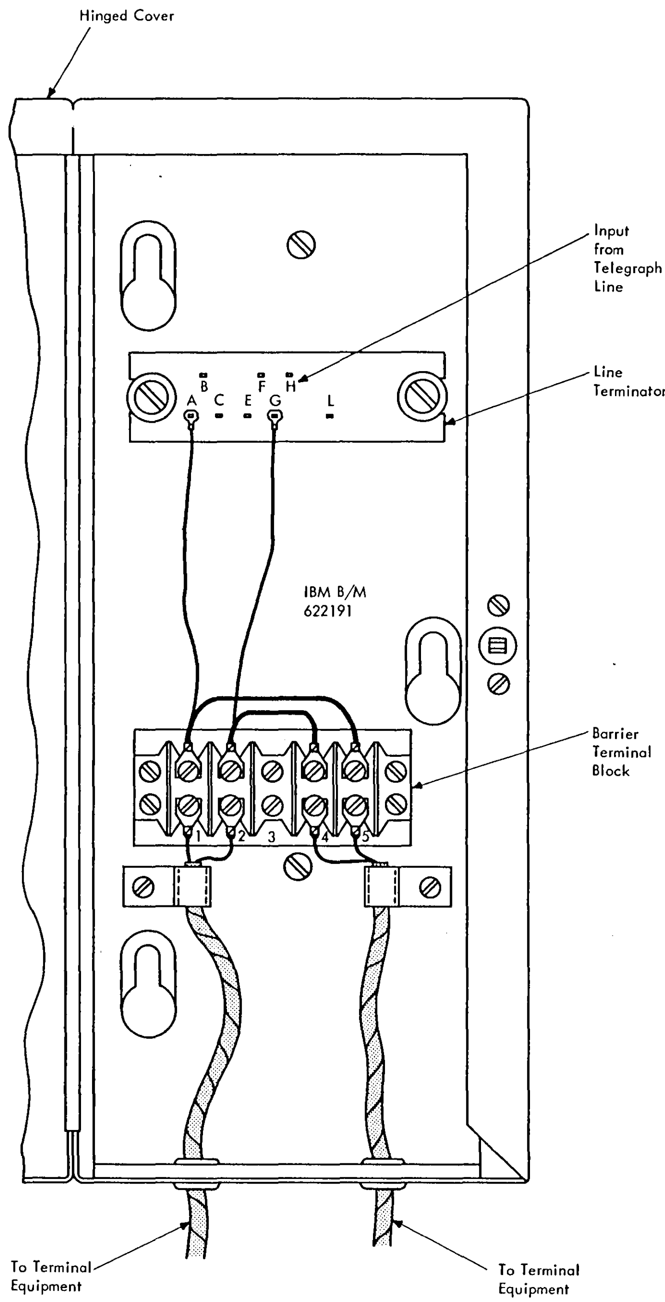


FIGURE 1-12. IBM LINE TERMINATOR BOX

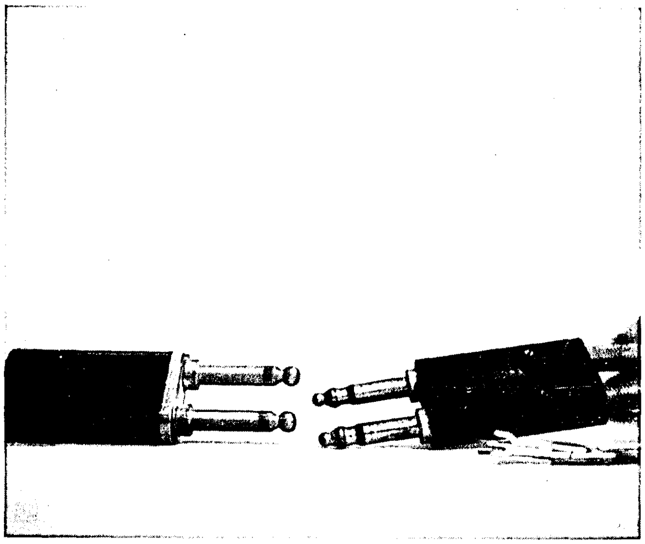


FIGURE 1-13. PLUGS AND CORDS (TELEGRAPH)

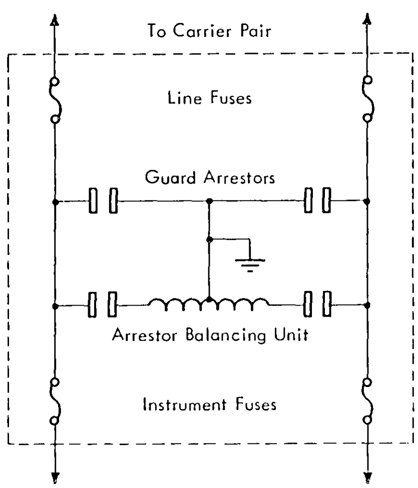


FIGURE 1-14. TELEGRAPH LINE ARRESTOR

Type of Line	Maximum Frequency	Repeater Spacing Miles
Submarine Cable	20.8 cps	2,148
Single Open Wire, Grounded	25 cps	250
Single Open Wire, Grounded	60 cps	250
Multipair Cable Pairs	30 kc	18
Multipair Cable Pairs	60 kc	15
Open-Wire Transposed Pairs	30 kc	150
Open-Wire Transposed Pairs	60 kc	100
Open-Wire Transposed Pairs	150 kc	60

FIGURE 1-15. TELEGRAPH REPEATER SPACING

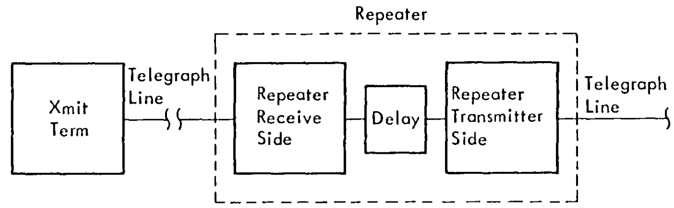


FIGURE 1-16. TELEGRAPH REGENERATIVE REPEATER

character, although delayed one bit time, is effectively recreated by the repeater. The repeater contains its own power supply. Thus the output signal should have good amplitude as well as waveshape. The emitters latch up at the end of the character and wait for the next start bit. Figure 1-17 shows the transmitted telegraphic data as well as the input and output of the repeater.

Electronic Repeaters

The electronic repeater serves the same function as the electromechanical repeater. The electronic repeater is much more versatile because it employs electronic circuitry in place of emitters and is generally not as code-sensitive.

REPRESENTATIVE TYPE EQUIPMENT

One type of telegraph equipment frequently used in common-carrier systems is manufactured by the Teletype Corporation. When marketed by the telephone companies, the equipment is called Teletype. When marketed by Western Union, it is called Teleprinter.

As in the IBM terminal line, the basic purpose of the various common-carrier terminals is that of input/output devices used to transmit and receive information.

The configurations of station equipment available to perform the requirements of any given application are many and varied. Only the most widely used are discussed below:

Receive-Only Page Printer (Figure 1-18) (often referred to as an RO). As its name implies, this device prints page copy of information being received over a communication line. It is a device having no keyboard, although it does have external positioning keys; for example, carriage return, line feed, etc.

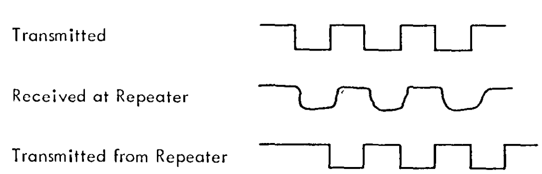


FIGURE 1-17. TELEGRAPH REGENERATIVE REPEATER WAVEFORMS

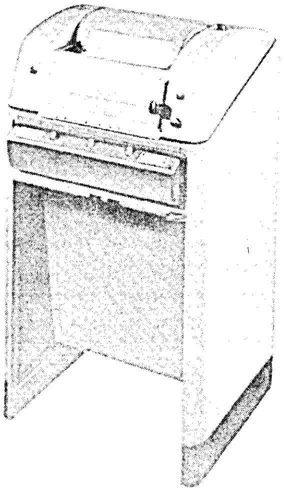


FIGURE 1-18. RECEIVE ONLY PAGE PRINTER (RO)

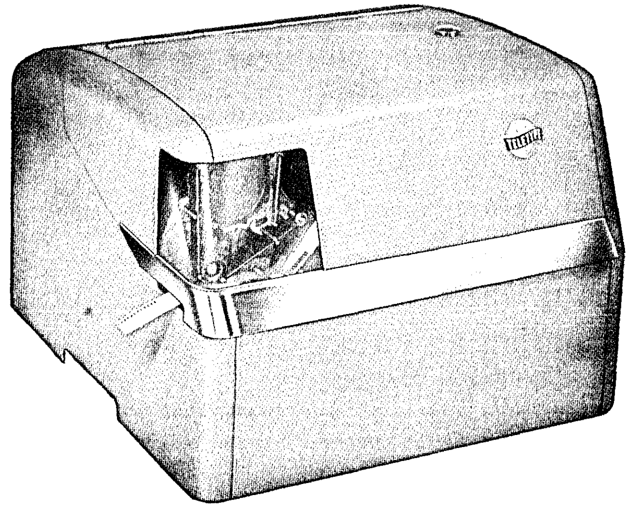


FIGURE 1-20. RECEIVE ONLY TYPING REPERFORATOR (ROTR)

Keyboard Sending and Receiving Unit (Figure 1-19) (KSR). This device contains a page printer, just as an RO, but it also contains a typing keyboard which allows data to be transmitted to a communication line. In addition, while data is being transmitted to the line, page copy is being printed on the receiver printer. Both units are housed in one cabinet.

Receive-Only Typing Reperforator (Figure 1-20) (commonly referred to as an ROTR). This is a receive-only device whose output is in the form of punched paper tape which, in addition to containing the punched representation of the received character, contains the received printed characters along the edge of the tape. An ROTR is always hooked directly to a communication line, since it uses line signals to perform its punching functions.

FIGURE 1-19. KEYBOARD SEND-RECEIVE (KSR)

Perforator (Figure 1-21). This device is used off-line in conjunction with a keyboard to prepare tape for transmission via a transmitter distributor.

Keyboard Typing Reperforator (Figure 1-22) (commonly referred to as a KTR unit). This is a device containing a keyboard and a typing perforator. It can be used to punch and print paper tape while sending the signal to the line, or it may be used to receive printed and punched tape from the line. It cannot, however, be used off-line to prepare tape for transmission via a transmitter distributor.

Transmitter Distributor (Figure 1-23) (most commonly referred to as a TD). This device reads the paper tape and converts the punched holes to serial electrical signals for transmission to the line.

Reperforator Transmitter (Figure 1-24) (most commonly referred to as an RT). This device is used primarily on private switching systems to automatically route messages from one station to another. This unit contains a typing reperforator that is connected to an incoming (receive) line and a transmitter distributor that is connected to an outgoing (send) line. The message usually is received in its entirety, punched in paper tape, before being transmitted by the TD. This store-and-forward operation allows for differences in line speeds between incoming and outgoing lines.

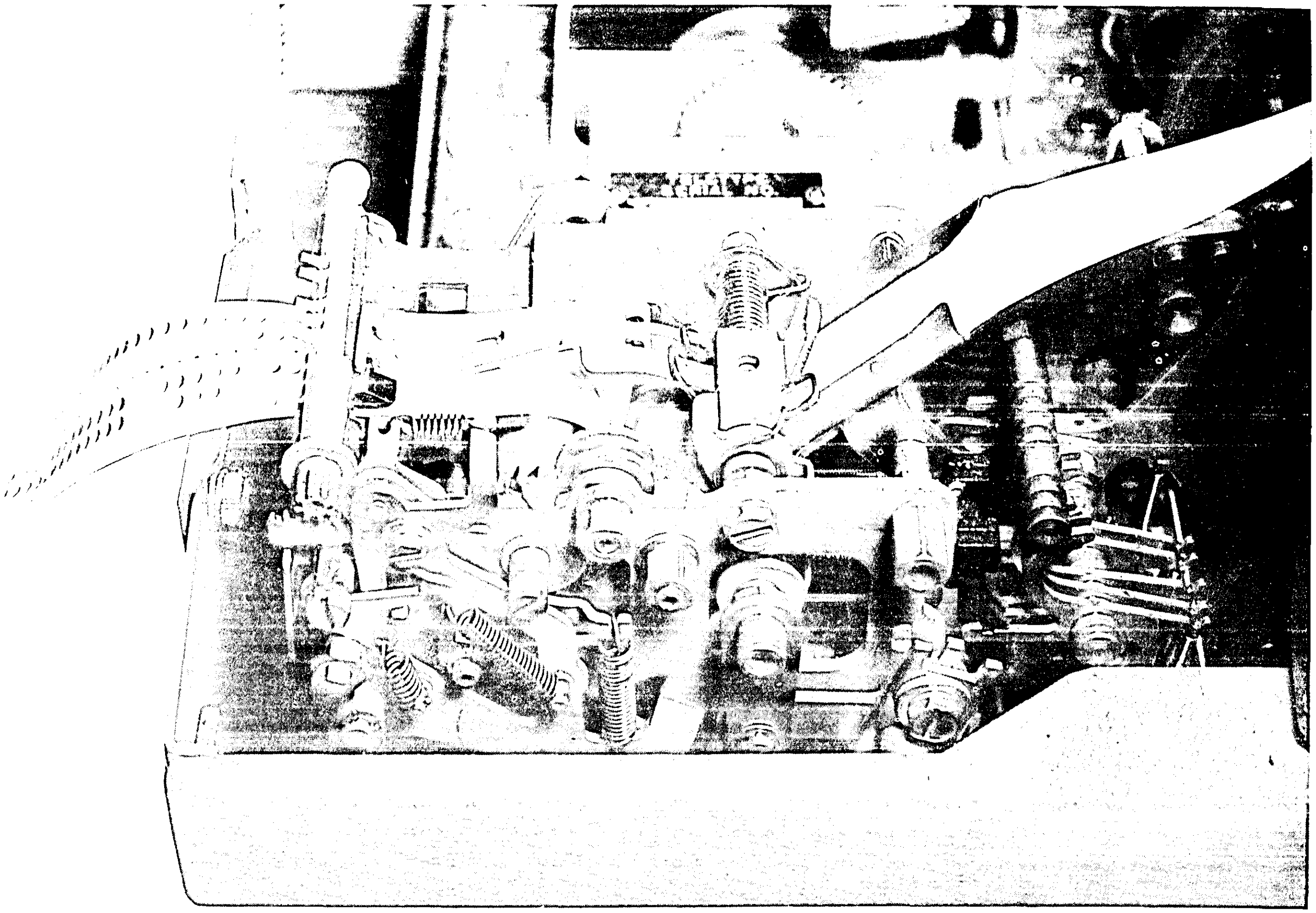


FIGURE 1-21. TELEGRAPHIC PERFORATOR (PERF)

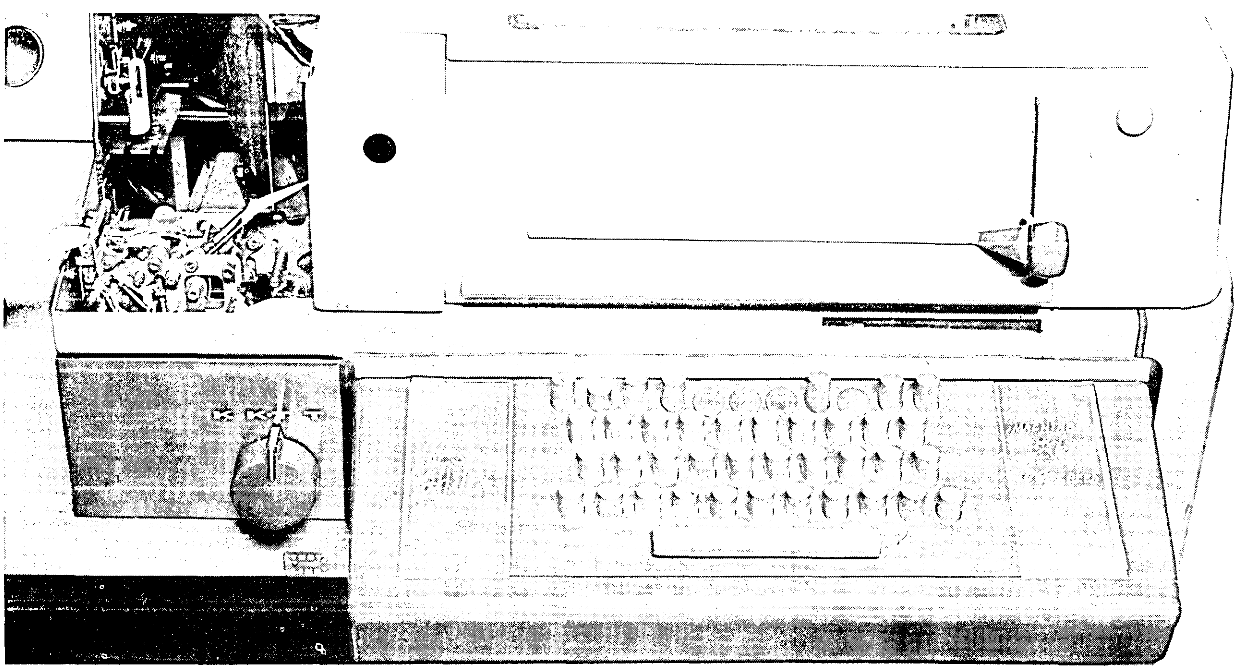


FIGURE 1-22. KEYBOARD TYPING REPERFORATOR (KTR)

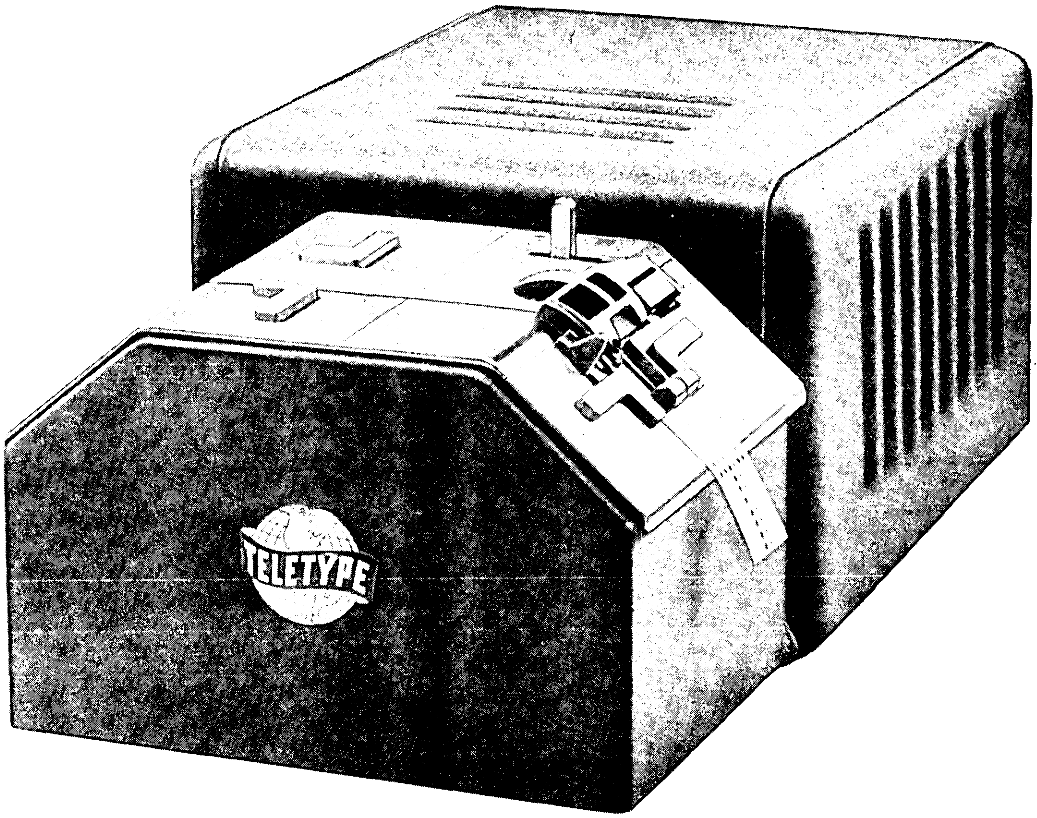


FIGURE 1-23. TRANSMITTER DISTRIBUTOR (TD)

Automatic Sending and Receiving Unit (Figure 1-25) (most commonly referred to as an ASR). This unit is a multi-functional device containing a keyboard, perforator, page printer, and tape transmitter. This combination of units may be used on-line or off-line and, in some cases, on-line and off-line simultaneously. For example, it is possible for the ASR to be in the act of preparing a tape for transmission, with the three-position switch in the K-T (keyboard-tape) position (thereby placing the keyboard and perforator in an off-line state), while at the same time receiving a message on the page printer and perhaps on an associated reperforator.

BASIC TELEGRAPH CIRCUIT

Telegraph transmission is built around the current loop concept. That is, data is transmitted by opening and closing a current path that connects both the sending and receiving terminal. The data transmitted by one terminal may be converted to other modes to facilitate long distance transmission but will always be converted back to a current loop to activate the receiving terminal. Figure 1-26 shows two terminals connected to a telegraph line. Two polar relays are required per terminal. The receive polar relay has two windings: one is in series with the telegraph line and the second is the bias winding. The send polar relay points are also in series with the line. When two terminals are connected as shown in Figure 1-26, a current loop is created. The dc power supply, provided by the common carrier, is the current source for the loop.

The common carrier is reponsible for insuring that the current in the loop is 62.5 ma plus or minus 2.5 ma. A number of operating voltages are used on the telegraph lines, depending on the type of carrier and the distance from the customer to the central office. For the maximum case, the voltage to ground is 130 volts with 260 volts across the line.

When neither terminal is transmitting, the 62.5 ma current is in the loop. When either terminal starts transmitting, the send polar relay within that terminal is energized and de-energized by the serialized data. A Mark (bit) condition is indicated by current in the loop. A space (no-bit) condition is indicated by no-current in the loop. The receive polar relays at both ends are operated by the transmitted data.

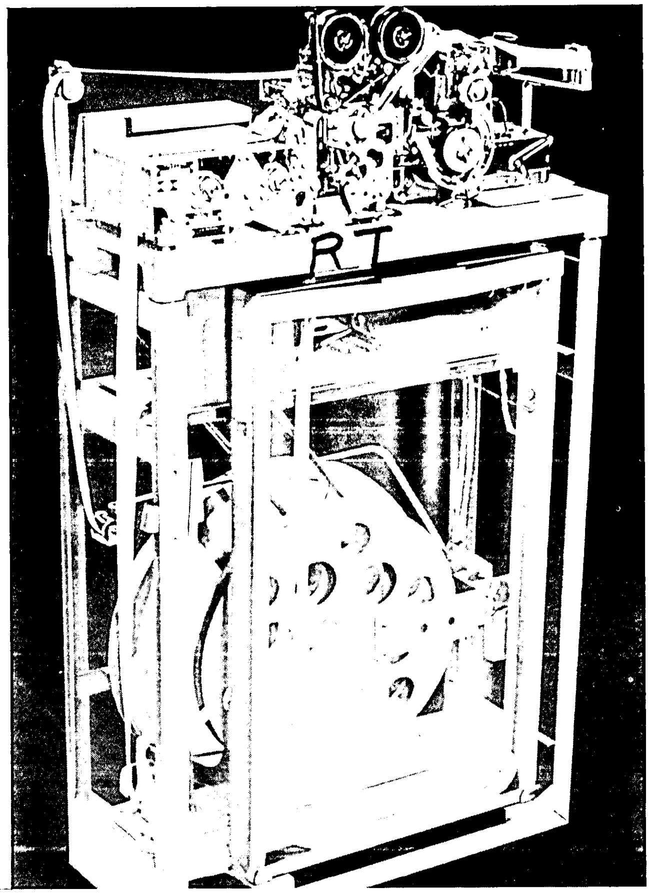


FIGURE 1-24. REPERFORATOR-TRANSMITTER (RT)

Usually, no provisions are made to use output of the receive polar relay of a transmitting terminal although its output is a replica of the transmitted data. The exception to this is the IBM 2701 Data Adapter Unit. The 2701 uses the received polar relay output as a feedback check while transmitting.

When servicing a terminal utilizing telegraph lines, the time will come when it will be necessary to remove the polar or disconnect the lines. It is imperative that the telegraph lines never "run open". That is, an open-circuit condition, such as created by removal of either the polar relays or the lines, should always be terminated or loaded with a resistor. A resistor rated at 200-300 ohms, 10 watts is used. The terminating resistor is automatically switched into the loop in the IBM 2701 Data Adapter Unit whenever terminal power is off. The IBM 1050 Data Communication System provides the terminating resistor, and a service-operate switch to service will insert the terminating resistor across the line. Returning the switch to operate removes the resistor from the loop. Figure 1-26 depicts the protective resistor's location in the circuit.

TELEGRAPH SIGNAL DISTORTION

Telegraph signal distortion is an important and never-ending problem commonly encountered when working with equipment attached to telegraph line facilities. The common carrier has facilities to monitor and measure signal distortion and often does so on a full-time basis. True to form, it is usually the unmonitored line that develops trouble. Due to this fact, a knowledge of distortion types and their causes is essential. Distortion measurement and diagnostic techniques will be covered in a later session.

There are four fundamental types of distortion which adversely affect the fidelity of telegraph signals:

1. Bias Distortion. In telegraph applications, bias distortion is characterized by Mark or Space pulses which are consistently too long or too short. This means that the total time allocated to one Mark and Space bit never changes; only the length of the Mark or Space element changes. If an alternate Mark/Space pattern were transmitted with an equal amount of time between transitions, the received signal will probably have a percentage of marking or spacing bias. This may be caused by the characteristics of the terminal, data set, or by an unequal rate of transmission. When the Mark pulses appear lengthened, the Space pulses will be shortened. This condition is called Marking Bias. When the Mark pulses appear shortened, the Space pulses will be lengthened. This condition is called "Spacing Bias" (Figure 1-27). Bias distortion is measured as a percentage. For example, if the marking pulses of a particular character are 20 percent longer than they should be, 20 percent marking bias exists.
   A maladjusted polar relay that holds too long in the marking or spacing condition can cause bias distortion. The procedure for correcting bias distortion problems is covered in a later session.
2. End Distortion - In Start-Stop telegraphic signals, the shifting of the end of all marking pulses from their proper positions in relation to the beginning of the start pulse is called "end distortion." Marking end distortion denotes a lengthening of the marking bit. Spacing end distortion denotes a lengthening of the spacing bit (Mark bit is shortened). See Figure 1-28.
   A possible offender creating marking end distortion is line capacitance. The capacitance will cause the voltage delay slope of the Mark

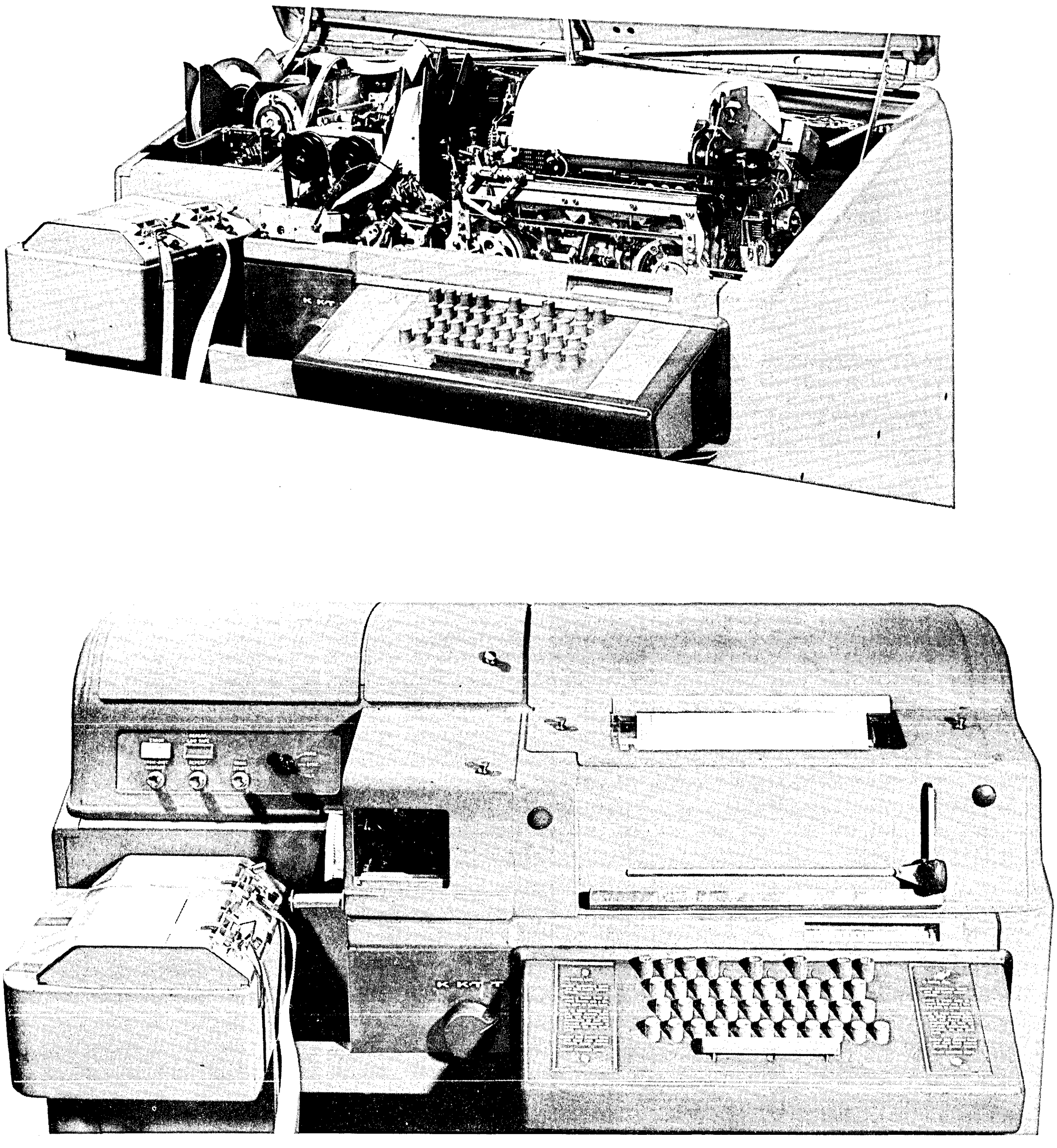


FIGURE 1-25. AUTOMATIC SEND RECEIVE MODEL 28, ASR 28

to Space transition to be lessened. Consequently, the voltage present after the actual Mark-Space changeover can be sufficient enough to hold a relay marking. Spacing end distortion can result from improperly functioning repeaters.

3. Fortuitous Distortion. Fortuitous distortion (Figure 1-29) is caused by crossfire (crosstalk) between two or more circuits, atmospheric noise, power line induction, lightning storms, dirty transmitting contacts, and similar disturbances. It must be emphasized

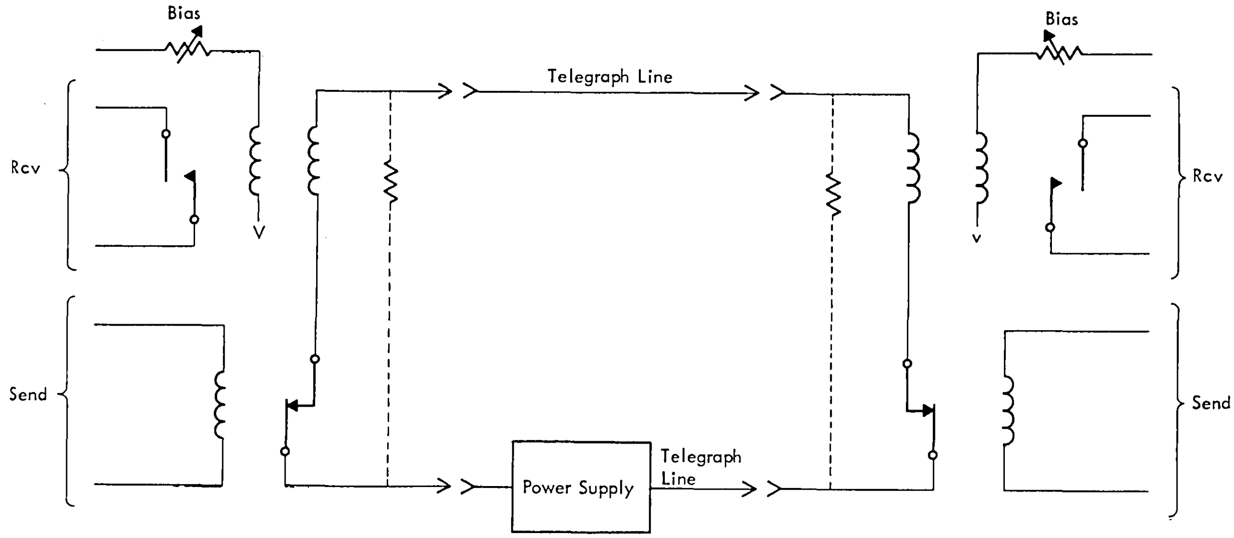


FIGURE 1-26. TELEGRAPHIC LINE CIRCUIT

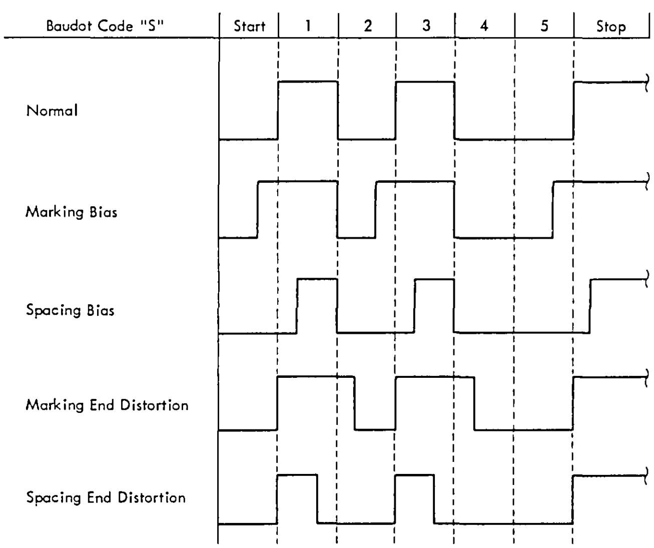


FIGURE 1-27. TELEGRAPHIC SIGNAL DISTORTION

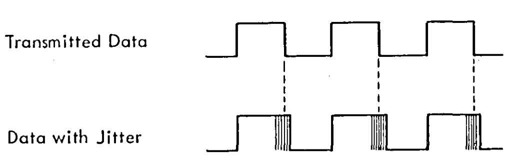


FIGURE 1-28. JITTER

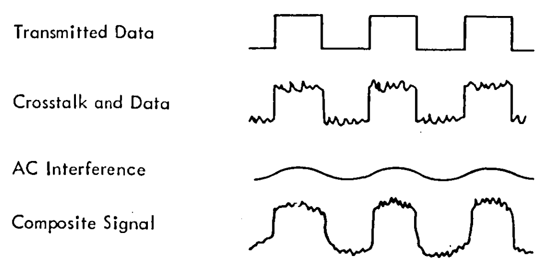


FIGURE 1-29. FORTUITOUS DISTORTION

that fortuitous distortion means random disturbances. Another example of fortuitous distortion is "jitter". Jitter is the random variation in bit length due to noise or modulation process. Jitter cannot, for the most part, be adjusted. Oscilloscope observation of a specific character being received continuously will reveal jitter. Measurement of the maximum variation will reveal peak jitter in percent. Jitter will be covered further in the telegraphic diagnostic session. Figure 1-28 depicts jitter as it would be observed on an oscilloscope.

4. Characteristic Distortion. The normal and predictable distortion of data bits produced by inductive and capacitive constants of the line as well as distortion introduced by the sending terminal and regeneration points is called "characteristic distortion".
   Figure 1-30 (a) depicts a type of characteristic distortion generated by the sending terminal.

(a) Transmitted Signal

(b) Received Signal

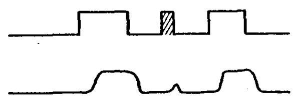


FIGURE 1-30. TELEGRAPHIC LINE DISTORTION

The shortened bit (shaded) can be a result of dirty or maladjusted sending contacts. Figure 1-30 (b) shows the resultant signal as it would be received if inductive and capacitive characteristic distortion were included.

The total of these four forms of signal distortion is known as "cumulative distortion" of the signal. The cumulative distortion of a line is usually denoted as a percentage. For example, the rule of thumb for acceptable cumulative distortion for start-stop telegraphy is 35 percent. It is interesting to note that 35 percent pure bias or end distortion is much more tolerable than just 20 percent of fortuitous distortion. For this reason, it is important that the different forms of distortion be distinguishable.

It is most important that we be able to separate characteristic distortion from the other forms of distortion. If we are able to establish that only a certain portion of the signal is disrupted, we can immediately eliminate the entire system between the sender and receiver and say that the sending equipment is the cause of the distortion. The diagnostic and measurement aspects of distortion will be covered in Session 3.

The text for Session 1 is concluded. Answer the review questions and proceed to Session 2. If you answer any questions incorrectly, you should review the appropriate portions of the text before proceeding.

REVIEW QUESTIONS

1. The normal value of line current encountered in telegraphic circuits is _____ milliamperes.
2. A Mark is represented by (current/no current on the line.
3. The device used to reshape telegraphic signals on the line is a _______ _______.
4. An ROTR is a ______ ______ ______ _______.
5. What job does a TD perform?
   ____
   ____
   ____
   ____
6. When using a telegraph interface, what appears at the receive polar relay points when the terminal is transmitting?
   ____
   ____
   ____
7. The type of distortion which is erratic and unpredictable is called _____ or _____ distortion.
8. The fixed distortion encountered in telegraph circuits is referred to as ________ distortion.
9. If the Mark to Space transition of a telegraphic data signal occurs early, _____ _____ distortion exists.
10. If the Mark bit is lengthened as a result of an early Space to Mark transition of a telegraphic data signal, the distortion is known as _______ ___________.
11. The space bit is (lengthened/shortened) as a result of Marking Bias distortion.
12. The major factors of a telegraphic line configuration which can produce end distortion are ________ and ________.
13. The interference of one telegraphic circuit with another is called ________.
14. If the sending polar relay of a transmitting telegraphic terminal is slow to drop out when de-energized, the type of distortion which would result is _______ _______.
15. The tolerable distortion limit in telegraphic circuits is about ________ percent.

TELEGRAPHIC SWITCHING SYSTEMS

This session will consider the functions and capabilities of a cross section of the telegraphic message switching systems provided by the common carriers. These systems are of particular interest because IBM equipment is being frequently used to provide the supervisory control for these systems. In addition, the message formats of one of these systems will be covered in detail. This session will also point out the functions and operations of the special units found within the teletypewriter attached to these systems.

Highlights

- Types of telegraphic message switching systems
  - AT&T 81D1
  - AT&T 83B2
  - WU Plan 115A
- 83B2 system message formats
  - Addressing
  - Polling
- Special functional units
  - Stunt box
  - Function generator

TYPES OF SWITCHING SYSTEMS

AT&T Fully Automatic Teletypewriter Switching System 81D1

The 81D1 system provides for a continuous flow of messages between the various stations on private-line teletypewriter networks involving a multiplicity of lines and stations. It functions in such a manner that a message may be sent from any sending teletypewriter and recorded on any desired receiving teletypewriter or group of teletypewriters in a network without requiring manual handling or operating attention other than the original perforation of tape at the sending station and the removal of the typed message from the receiving machine or from machines to which it was directed. The switching operations are entirely automatic and are under the control of directing characters punched at the head of each message in the original transmitting tape and end-of-message characters punched at the end of each message.

Individual line circuits are full duplex and may be operated at either 60, 75, or 100 words per minute.

Different sizes of switching offices, the number of switching offices in a system, the number of trunks between switching offices, the number of stations in a system, the amount of traffic for local delivery in the vicinity of a switching office, the quantity of multiple-address traffic, and a number of other variations all must be considered when a system is designed.

Each station in the system is assigned a two-letter code. In order to direct a message from any sending station in the system to any receiving station, the operator punches in the sending tape the two-character code of the desired station, followed by the message. This tape is then transmitted. No further action regarding this message is required on the part of the station operator. The message is received at the controlling station and is repunched in paper tape. The message is then automatically read and switched to the correct output line under direction of the two-character designation code. Figure 1-31 depicts the 81D1 system.

AT&T Selective Call System 83B2

The 83B2 system is a half-duplex private teletype selective call system provided by American Telephone and Telegraph. The 83B2 system consists of up to

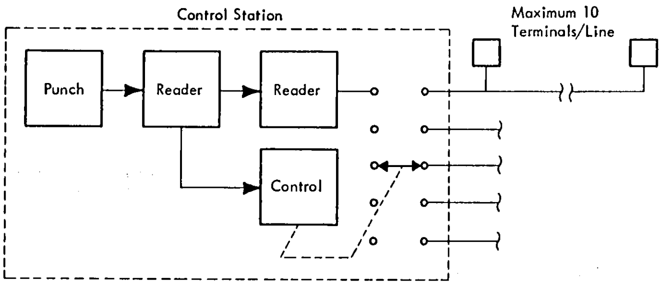


FIGURE 1-31. 81D1 SYSTEM

40 Model 28 teletypewriters arranged so that a master (control station) can address (send) data to any individual teletypewriter and poll (request) data from any teletypewriter. Figure 1-32 depicts a possible configuration of an 83B2 system.

Note that this system is arranged with a maximum of 20 terminals per line. Each terminal within the system is assigned a two-character address. The controlling station is switched to either of the two lines and has the ability to poll and address the terminals on each line. A message that is to be transmitted from a terminal on line 1 to a terminal on line 2 requires that the controlling station receive the original message from terminal 1 and then forward it to the correct terminal on line 2. The operator at the controlling station switches the message under control of the directing characters at the head of each message. A message transmitted between terminals on the same line does not require operator intervention. The system can operate at speeds of 60, 75, and 100 words per minute.

Western Union Plan 115A

The Western Union Plan 115A is similar in all respects to the AT&T 83B2 system.

83B2 MESSAGE FORMAT

The messages transmitted within the 83B2 system have two basic fixed formats. These formats (addressing and polling) are developed in the following paragraphs.

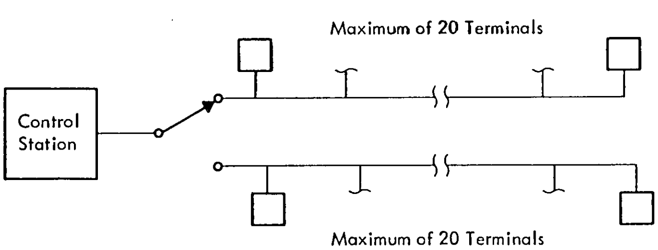


FIGURE 1-32. 83B2 SYSTEM

Addressing Format

All messages, directed or addressed to a particular terminal, are preceded by a Call Directing Code (CDC). This code consists of two TTY characters and a letters shift character. Any characters other than T, O, M, V, H, and Y may be used. The first two characters of the sequence determines which remote 83B2 terminal will receive the text of the message to follow. The remote terminal recognizes the CDC sequence and mechanically unlocks the terminal. A letters shift character rounds out the sequence by insuring that the remote terminal is in letters shift. If a message is to be broadcast (sent to all terminals in one lump), a separate CDC may be assigned to all terminals. In this case all the terminals respond as if they were being addressed.

At this point the addressed terminal should respond by transmitting a V. This response indicates that the addressed terminal is in fact ready to receive. The addressed terminal must have power on and paper tape installed in the paper tape punch to enable the positive response. If neither of these conditions exist, a no-response (negative response) condition will prevail. The controlling or addressing terminal will wait 10 seconds for the positive response. If the positive response is not received, the controlling terminal will advance to the next CDC and associated message. In the case of broadcast, only one terminal in the system will respond. The customer determines which terminal is assigned to respond. When the controlling station receives the positive response, it will continue with the message.

Next comes the text portion of the message. The message is transmitted to all terminals on the line but only the terminal selected will print or punch. In the case of broadcast, all the terminals that recognized the broadcast CDC will operate.

Following the text is the EOM/EOT (end-of-message or end-of-transmission) sequence. This sequence terminates the text transmission. It also selects and locks all the terminals in the system in preparation for the next CDC sequence. The EOM/EOT sequence consists of a figure shift code, H, and a letters shift code. That completes the message format for addressing. Refer to Figure 1-33 for a review of the complete addressing format as it would be when transmitted from paper tape.

Polling Format

When polling a remote terminal, the controlling station first transmits an EOM/EOT. This sequence selects and locks all the remote terminals. Following the EOM/EOT is a Transmitter Start Code sequence (TSC). The TSC determines which terminal is being polled and consists of two alpha characters.

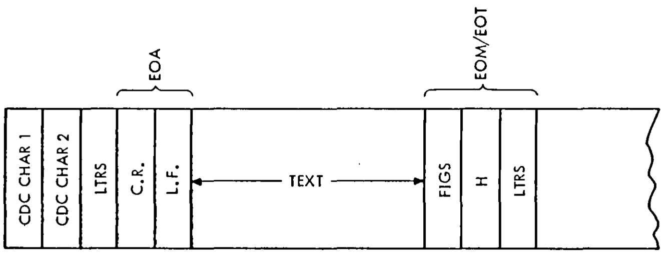


FIGURE 1-33. FORMAT OF TAPE MESSAGE, 83B2 SYSTEM

If the polled terminal is ready to transmit, it will be unlocked and thus allowed to send its message. The message is considered to be its positive response. If the polled terminal is not ready, it will transmit a V which is considered to be a negative response when polling. A power-off condition at the remote terminal will prevent any response and therefore will initiate a 2-second timeout of the controlling station. The 2-second timeout is considered to be a negative response.

An EOM/EOT should follow the text to select and lock the terminals in preparation for the next poll. Either the controlling station or the polled station may transmit this sequence. If a more detailed approach to polling and addressing is required, refer to Figures 1-34, 1-35, and 1-36.

SPECIAL FUNCTIONAL UNITS

Stunt Box

The most significant development of the Model 28 teletypewriter was the development of the stunt box control mechanism. One of the major shortcomings of earlier models of the teletypewriter was the inability to control their own peripheral (input/output) equipment automatically. That is, they weren't able to remotely start output devices, to recognize Start-of-Message (SOM) and End-of-Message (EOM) sequences. The resultant loss of line time (due to the long timeout needed to bid and contend for the line) on the already slow 75-wpm multi-station lines created a definite need for an automatic method of controlling the terminal equipment.

The following paragraphs deal primarily with the addressing and polling concepts of the private line communication system in general and the relative roll of the stunt box within it.

The stunt box is mounted physically on the Model 28 printing unit and responds to keyboard or line signals. It is an electromechanical device, with a mechanism for translating discrete electrical pulses into mechanical motion (this initiates further mechanical or electrical actions to perform specific operations). It is the recognition and translation of discrete characters, in combination with the recognition of character sequences, which facilitate the automatic control of a terminal. Therefore the stunt box enables polling and addressing control of multi-station lines.

The line control (addressing-polling format) characteristics may be generalized as follows:

1. Recognition of the SOM and EOM sequences. These three-character sequences, normally the same for both functions (the exact sequences for the 83B2 system are covered later in this session), induce a receive-select condition within the stunt box. In this state, the stunt box is monitoring for a combination of two or more characters that will address a terminal component.
2. Recognition of Unique Addressing Characters
   a. Call Directing Codes (CDC's). On recognizing this combination of characters, the stunt box unblinds all of the terminal receive equipment hooked to the line. This includes all RO reperforators, page printers, etc. At the same time, a stunt box feature responds to the calling station with a unique character (usually a V) to indicate that it is in the receive-print mode.
   b. Transmitter Start Code (TSC). On recognizing this sequence, the stunt box does one of two things. If there is tape in the TD, the stunt box unlocks the transmitter, and the tape is transmitted. If, however, there is no tape, a stunt box feature responds to the polling station with a V, indicating a no-traffic condition.
3. Recognition of End of Addressing. The recognition of this configuration of characters by the stunt box places all of the selected terminals in the print text mode and terminals which have not been selected into the nonprint text mode.
4. Recognition of EOM. Places all of the terminals in the nonprint receive control mode, which is similar to an idle condition. Note that the CDC, TSC, etc., characters are unique only from the standpoint that they are received in sequence. Unless preceded by the necessary control functions (SOM-EOM, etc.), the stunt box is not affected.

The operation of the stunt box may be summarized as follows:

a. Mechanically initiates internal functions within the printers, for example, letters shift, figures shift, etc.
b. Electrically controls functions within the printers; for example, unlocks the print mechanism.

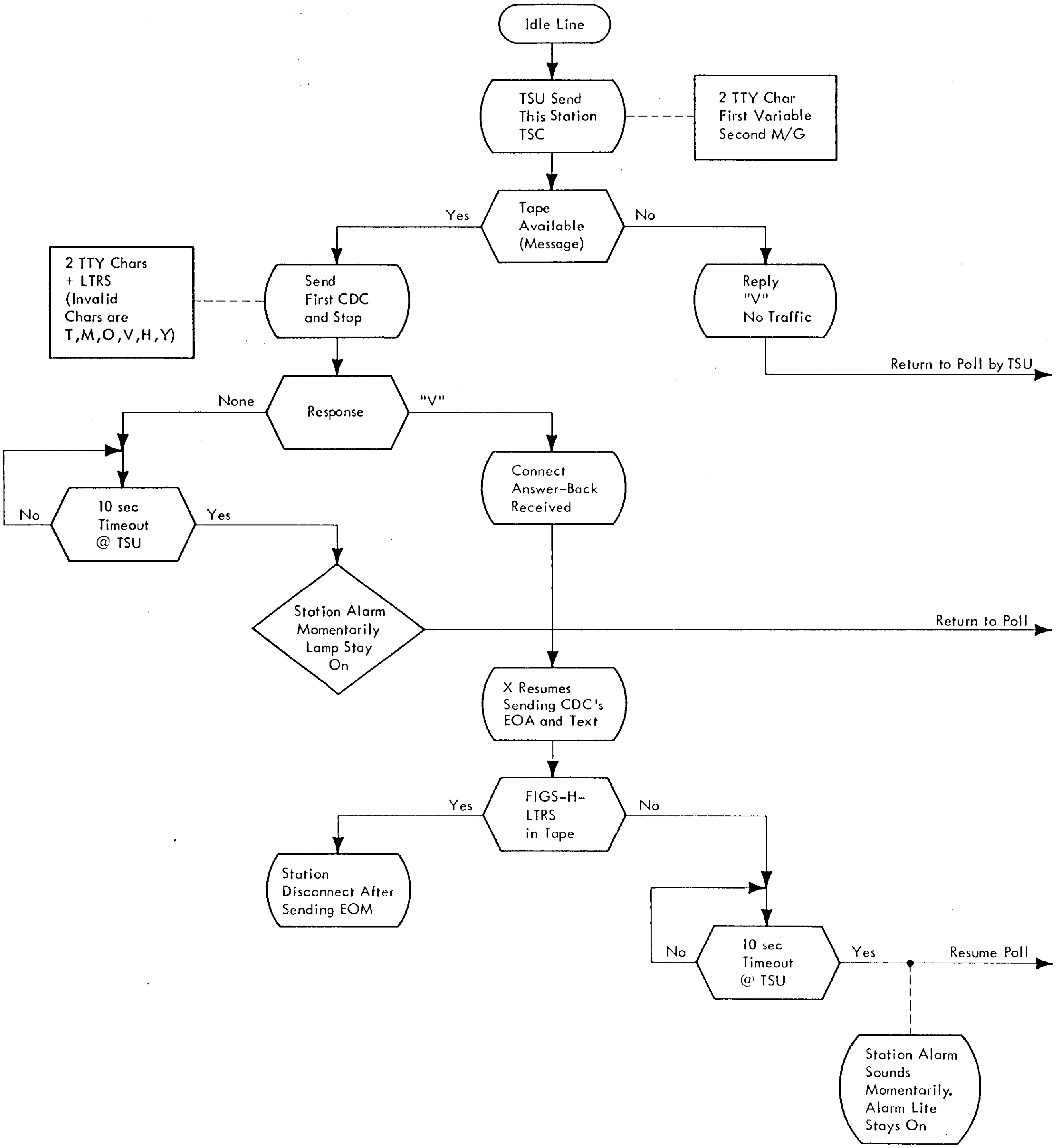


FIGURE 1-34. BASIC OPERATION 83B2, SCU SENDS MESSAGE

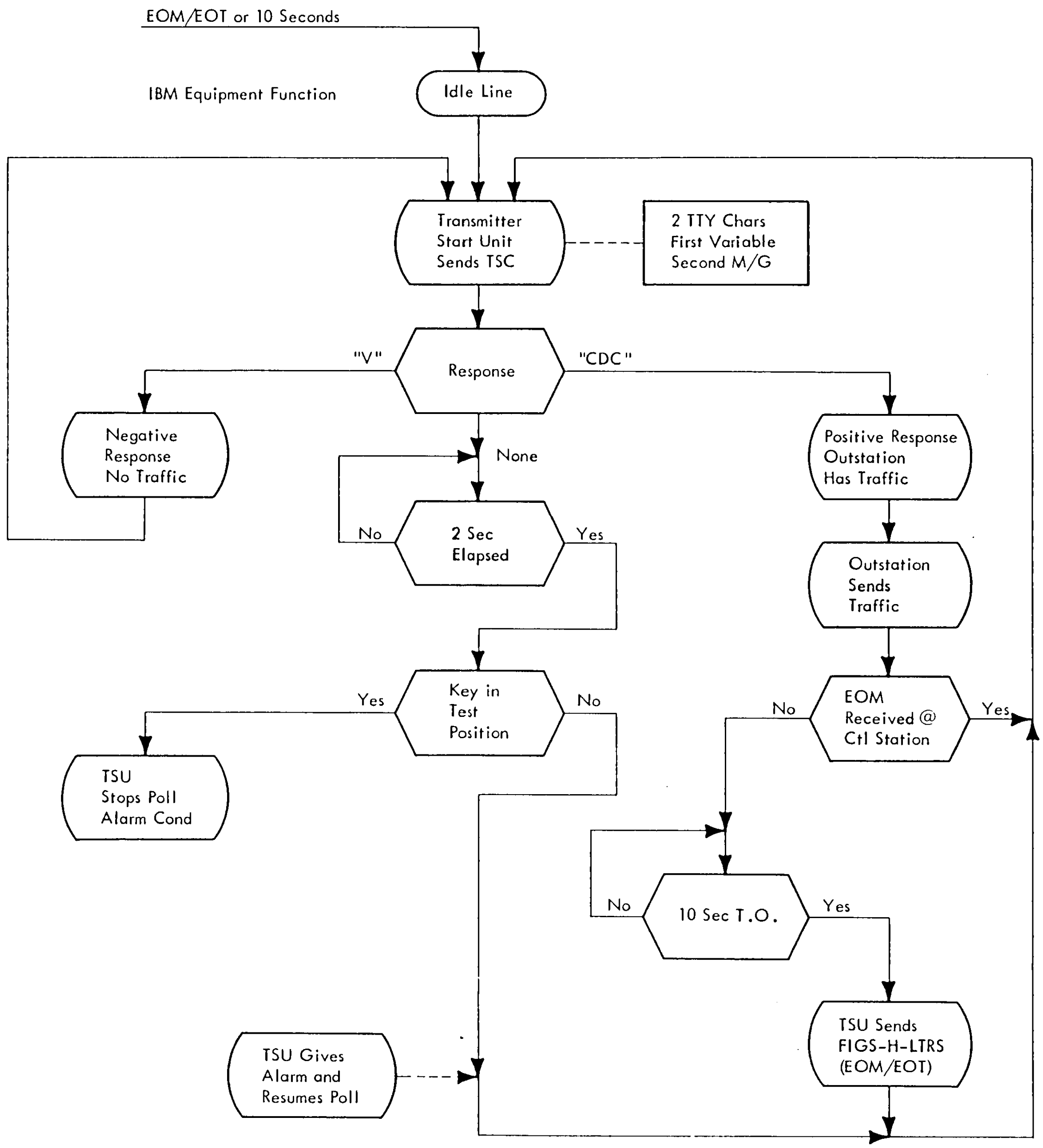


FIGURE 1-35. OPERATION 83B2, TSU POLLING

FIGURE 1-36. OPERATION 83B2, SCU RECEIVES MESSAGE

c. Electrically controls external equipment; for example, starts TD, etc.

Function Generator

The function generator is a electromechanical device mounted physically in the Model 28 teletypewriter. The function generator generates character sequences required for the addressing and polling control of multi-station lines. An example of one of these sequences is the EOM/EOT sequence (FIGS, H, LTRS). The function generator creates its character sequence outputs when actuated by either mechanical or electrical means.

The text for Session 2 is concluded. Answer the review questions and proceed to Session 3. If you answer any questions incorrectly, you should review the appropriate portions before proceeding.

REVIEW QUESTIONS

1. Non-printing telegraphic codes may be used to perform external control functions at a telegraphic terminal through the use of a ________ ________.

2. The device incorporated in a teleprinter to enable the transmission of a complete sequence of telegraphic characters as a result of a single key operation is called a________ ________.

3. The term applied to the invitation to send traffic, which the master or control station sends to an outstation, is________.

4. The term applied to the procedure involving a direction from the master station for the outstation to receive traffic is________.

5. The positive reply from an outstation to a poll is________ ________.

6. When an outstation has been addressed and is ready to receive, it signals this condition to the master or control station by sending________ (AT & T 83B2).

7. The abbreviation CDC stands for ________ ________ ________ and TSC is the abbreviation for ________ ________ ________.

8. (TSC/CDC) is used for polling.

9. ________terminal(s) give a "V" answer-back in response to a broadcast message.

10. Completion of work with any terminal is signaled with EOT which consists of________ ________ ________.

TELEGRAPH LINE FACILITY DIAGNOSTICS

This session delves into the various methods employed in distortion measurement and compensation as well as in common carrier test facilities.

Highlights

- Distortion Measurement
- Common Carrier Tests

Initially, telegraph line facility problems show up as failures at the terminal ends of the line. Bad data and errors would be symptomatic of line facility difficulties. Because of this, the approach to telegraph line facility problems begins at the terminal.

Before it can be assumed that the line facility is, in fact, creating the supposed problem, the terminals themselves must be eliminated from suspicion. This can be accomplished through the use of terminal self-test, unit or terminal swapping techniques. Although terminal self-test and swapping techniques are adequate, the final determination of responsibility for the difficulty can be resolved by applying the old adage, "What goes up must come down" or, in our case, "What goes in (the send polar relay) must come out (the receive polar relay)." If the bit configuration of the data transmitted is not the same as the data received, the line facility is at fault. Once it is determined that the line facility is creating the errors, a check of line distortion is in order.

DISTORTION MEASUREMENT

As described in a prior session, we found that there were four forms of distortion:

1. Bias
2. End
3. Fortuitous
4. Characteristic

An oscilloscope will be required to prove the existence of any of these forms of distortion.

Distortion measurements are usually made while a character with alternate Mark and Space bits is being transmitted continuously. The use of a character with alternate bits facilitates an easy check of all forms of distortion. The oscilloscope is connected across a 10-ohm resistor that is inserted in series with the line (Figure 1-37). The 10-ohm resistor provides a voltage drop indicative of the current in the loop. A 10-ohm resistor is used because it provides an easy to convert peak-to-peak voltage to current translation. An oscilloscope with dual vertical input capability (e.g., Tektronix 561A or equivalent) is required.

Set-up:

1. Connect probes to 10-ohm resistor.
2. Set mode switch to Algebraic Add.
3. Invert Channel A.

In this mode, the oscilloscope is being used as a differential amplifier. The use of the oscilloscope in this manner eliminates the need to ground it to the telegraph line. Keep in mind that there is 260 vdc across the line and 130 vdc to ground.

Line Current Check

The first step prior to the actual distortion measurement should be a quick check of the line current. The common carrier is responsible for the line current and should correct any deviations from the acceptable 62.5 ma ($\pm$2.5 ma). To check the current, connect an IBM voltmeter in series with the line. Be sure to use the appropriate current range. In most IBM terminals, two lugs are provided to attach the meter leads. The lugs are in the line circuit, but normally are jumpered. After the meter is connected to the lugs, remove the jumper. This prevents the line from "running open" while attaching the meter. If the line current is found to be in question, the common carrier should be requested to run a check on the line current.

Transmit Unity M/S Ratio Check

Once it has been determined that the line current in the circuit is acceptable, distortion measurements

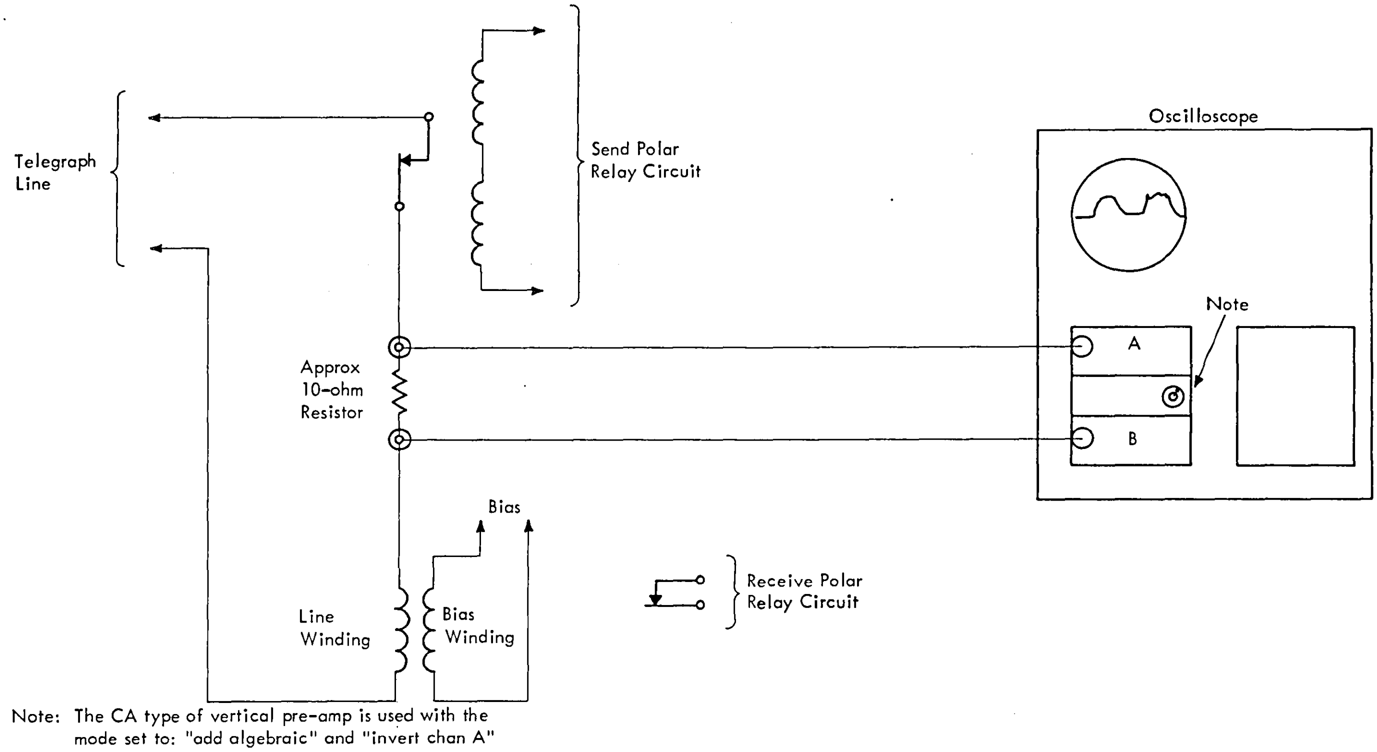


FIGURE 1-37. SCOPING TELEGRAPH CIRCUITS FOR DISTORTION

should be made. It is important to note that distortion can be introduced by either the sending terminal, receiving terminal, or the line facility. When checking for distortion, it is therefore necessary to decide which form of distortion we are checking and where in the circuit it is to be measured. The most logical approach would be to determine first if the sending terminal is creating a distorted signal. An example of distortion that can be introduced by the sending terminal is bias distortion. The transmitted signal must have a unity Mark -to-Space ratio. That is, the marking and spacing bit must be the same length. A poor Mark-to-Space (M/S) ratio would be indicative of an incorrectly adjusted transmit polar relay or possibly problems in the polar relay drive circuits. The measurements should be made at the terminal while it is transmitting.

Bias Winding Adjustment

A check of the receive polar relay output at the receiving terminal should be performed next. This check will reveal the existence of bias distortion introduced by the line facility or the receiving polar relay. To facilitate this measurement, the oscilloscope is connected to the output of the receive polar relay. If the receive polar relay is correctly adjusted, the oscilloscope will reveal a unity M/S ratio. If the M/S ratio is not correct, it indicates that the polar relay is being affected by line distortion and requires adjustment. The bias winding on the receive polar relay is adjusted to provide a unity M/S ratio output. The bias winding compensates for line distortion by varying the sensitivity of the polar relay. When the bias adjustment is correct, the polar relay will respond to the 50 percent current line and produce the required M/S ratio. See Figure 1-37.

Fortuitous Distortion Measurement

A measure of the fortuitous distortion present in a circuit is facilitated through the observation of bit jitter. Jitter may be measured by connecting the oscilloscope differentially across a 10-ohm resistor inserted in the line circuit. (See Figure 1-37). If a calculation of the jitter reveals that it exceeds 20 percent, a new line should be requested from the common carrier. It should be noted that the customer is responsible for contacting the common carrier regarding requests for line checks, new lines, etc., unless a Systems Maintenance Management Agreement is in effect with the customer. In this case, the IBM CE or field manager will call the common carrier and notify the customer of the action taken.

COMMON CARRIER TESTS

The common carrier is equipped with facilities to measure line current as well as to monitor lines for distortion. These facilities are not usually in service and must be requested. Distortion monitors are sometimes found in customer locations. These monitors are usually customer-purchased. A red light on the monitor will come on when a 20 percent distortion level is present. Some monitors may be adjusted for other distortion limits.

The text for Session 3, last session in Section 1, is concluded. Answer the review questions, using the text as reference. If you answer any questions incorrectly, review the appropriate portions of the text before proceeding. When you are ready to continue, contact your course administrator to take the final evaluation examination for Section 1 of Common Carrier Facilities for Teleprocessing.

REVIEW QUESTIONS

1. A line current of 60 ma should produce satisfactory terminal operation. (True/False)

2. The ratio of a Mark to a Space on a telegraph line without distortion should be________to ________.

3. The starting point for adjustment of the bias current of a polar relay is with ________ milliamperes flow in the bias winding.

4. The percentage of jitter at which a new line should be requested is________.

5. In order to check the "local loop" when sending on a telegraph line, you could scope: (what ?)

SECTION 2

ASYNCHRONOUS DATA COMMUNICATIONS

SESSION 1

TELEPHONE SYSTEMS

In this session you will become acquainted with the basic components necessary for telephone voice communications.

Highlights:

- Simple Local Exchange
- The Telephone Instrument
  - Transmitter
  - Receiver
  - Ringer
  - Coils

As originally developed, the telephone system was to provide voice communication. Today, these same facilities are used to provide for data communications at speeds up to 500,000 bits per second (bps). This portion of the course will first develop the telephone system as a method of voice communication and then expand to cover the necessary additional equipment for data communications.

SIMPLE LOCAL EXCHANGE SYSTEM

The minimum requirement of a telephone system will be met by the configuration of Figure 2-1.

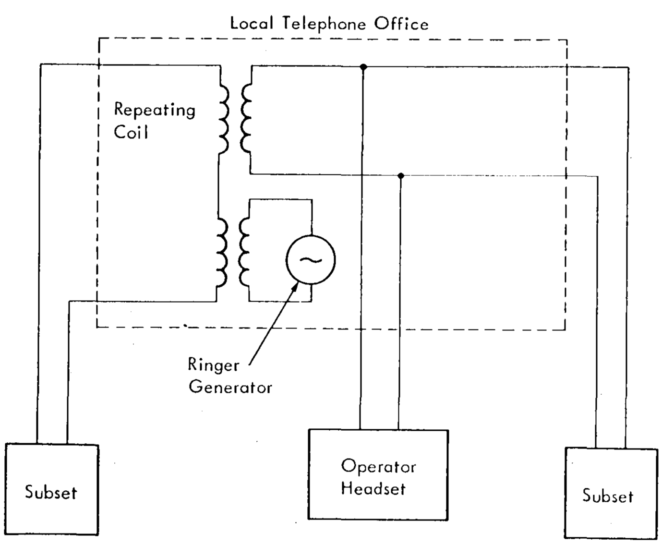


FIGURE 2-1. SIMPLE TELEPHONE SYSTEM

In this figure, the principal components are:

1. Telephone sets
2. Lines connecting telephones (called Subscriber Sets or Subsets) to the central office.
3. Switchboard at the central office providing for interconnecting subsets on different lines. Note operator's position for answering.

The telephone set consists of the following main parts (Figure 2-2.):

1. Transmitter
2. Receiver
3. Induction Coil
4. Switch Hook Contacts
5. Ringer

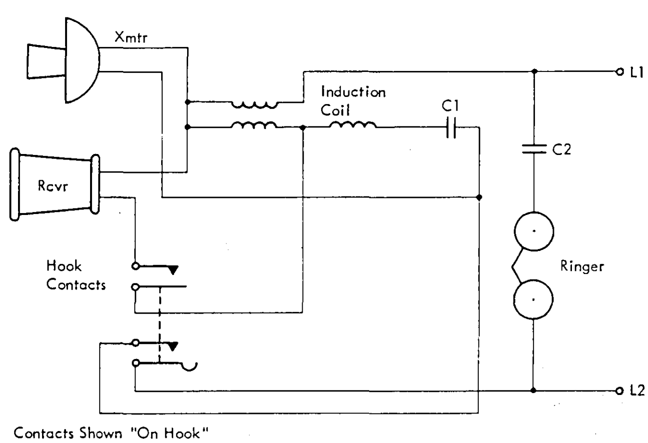


FIGURE 2-2. SUBSCRIBER TELEPHONE SET

The first step toward understanding the system is a review of the components used.

REVIEW OF COMPONENTS

The telephone Transmitter element is a carbon type microphone. Fluctuations of pressure on the diaphragm either cause compression of the carbon granules or allow them to expand. This results in a varying current flow through the transmitter and through the windings of the induction coil and the telephone line connected to L1 and L2. These fluctuations are the electrical image of the speaker's voice.

With the telephone "on-hook"(i. e., handset resting in cradle), the "switch hook" contacts are as shown in Figure 2-2. Note that no circuit exists from the transmitter element or receiver element to L2 unless the handset is "off-hook".

The Receiver element of the telephone is an electromagnetic device. A thin metal diaphragm is supported by its outer periphery a few thousandths of an inch above the pole pieces of the electromagnet coils. Any fluctuation in the current through the coils will change the force of the magnetic field between the diaphragm and the poles, resulting in a vibrating motion of the diaphragm corresponding in frequency and relative amplitude to the line signal. The vibrating diaphragm causes condensations and rarefactions of air pressure on the listener's ear, thus converting the electrical image of a voice back to sounds again.

The induction coil provides a method of coupling the receiver and transmitter elements both to the line, permitting dc current to flow through the transmitter but allowing only ac flow through the receiver (a function of capacitor C1). Later model telephones have special networks added to prevent excessive "side-tone". Side-tone is hearing your own voice in your receiver when talking, which tends to be annoying unless properly controlled. The windings of the induction coil provide three other functions:

1. Match impedance of transmitter.
2. Match impedance of receiver.
3. Match line impedance.

The final component in the telephone is the Ringer. Note that the ringer is coupled across the line by C2. This prevents current flow. When the telephone is "on-hook", the only load on the line is the ringer. No dc path exists and hence the central office does not detect a false "off-hook" condition as it would if C2 were not in the circuit. The basic ringer responds to a 20-cps ringer signal. In actual telephone line use, a frequency as low as 20 cps cannot be satisfactorily transmitted. To overcome this problem, the telephone company selects a frequency within the transmission capabilities of the line, such as 1,000 cps, and interrupts the 1-kc signal at a 20-cycle rate. The bell of the ringer cannot respond to 1 kc., but does ring on the 20-cycle interrupt rate. The subset shown is connected for private line service, with the ringer connected across L1 and L2. In party line service, the telephone company usually connects half of the ringers from L1 to ground and the other half from L2 to ground. This practice reduces the number of extraneous rings a subscriber hears. Additional reduction of unwanted rings can be obtained through the use of frequencies other than 1 kc, with tuned reed relays so that on an eight-party line, each subscriber hears only his own ring.

Now let's move from the subset to the line facility. Usually, as the telephone line leaves the subscriber's premises it passes through an arrestor box. The arrestor box is something like the lightning arrestor on your radio or TV set, and protects the telephone instrument from high-voltage surges on the telephone line.

The signal on its way to the central office may go either by open wire lines (strung across telephone poles and supported by glass insulators on the cross arms) or it may go over twisted pair cable in a lead sheath jacket (supported by a wire rope cable and hanger brackets, or perhaps run underground). Note at this point that either facility represents a Transmission Line (just the same as the twinlead or coaxial cable from your TV set to its antenna) and all of the same rules apply to its use and misuse.

The first open wire lines were constructed from #12 wire on about 12-inch centers, and as such exhibited a Characteristic Impedance (Zo) of about 600 ohms. Hence, today's standards of 600 ohms when dealing with telephone circuits. The twisted pair cables, however, have a Zo of about 90-150 ohms. In order to match cables of this impedance to equipment having a load or source impedance of 600 ohms, something must be done to "match" the two impedances to provide maximum undistorted signal power transfer. That "something" is the use of "Loading Coils", which provide a means of altering the effective impedance of cables to more nearly match the equipment.

Several items should be briefly considered in regard to transmission lines and detailed later. Since telephone lines consist of distributed capacity, inductance, and resistance, their impedance is not constant for all frequencies; therefore, the "loading" which may produce optimum signal power transfer at low frequencies is no longer satisfactory when we get to 2000 cycles. This problem is known as attenuation or loss. Another problem is: all frequencies are not propagated on the line at the same rate, but decrease in velocity with an increase in frequency. The characteristic is called Phase

Delay or phase distortion. The result of phase delay is: if 1-kc and a 2.5-kc signal are simultaneously injected at a source, the 1-kc signal will arrive at the load ahead of, and out of phase with, the 2.5-kc signal. These relative losses are measured in dbm, which you learned about in Introduction to Teleprocessing.

Well, at last we have reached the central office. Our telephone line is terminated in a repeating coil (Figure 2-1). Let's digress just a moment and consider the various types of coils we will encounter in telephone circuits and why they have different names:

1. Retardation Coil (Retard Coil) - One winding like a "choke" in a power supply. (Also used as loading coil).
2. Induction Coil - three windings. An audio-frequency coupling transformer which couples two circuits to one and usually provides impedance matching of both to the line.
3. Repeater or Repeating Coil - four windings. Again an audio-frequency transformer. The windings may be assigned as use dictates (parallel, series, separate).
4. Hybrid Coils - six windings. An audio-frequency transformer having flexible assignment of windings.

We will see during this course where each coil is used.

Now, back to the switchboard. The Repeater Coil transfers talk signals and ringer signals. In addition, there are certain dc "supervisory" circuits which bridge primary to secondary of the repeating coil so that a signal light will turn on at the switchboard as soon as a telephone goes "off-hook". These lights alert the operator to plug the operator's local headset into an answering jack on the switchboard and say "number please".

When you give the operator the number of the party you are calling, the operator plugs a cable, for the line on which you are calling, into the jack corresponding to the called line and activates the ringer at the called party's location. As soon as the called party lifts the receiver from the "hook", the dc supervisory circuits for the "called" line signal an "off-hook" condition with a light at the switchboard. The operator can now stop ringing and disconnect the local head set cord. You are now free to talk to your party. When you "hang up", the lights on the switchboard go out and the operator then knows it is all right to remove the connection you have been using.

The text for Session 1 is concluded. If you can answer all of the following study questions, proceed to the next session. If you answer any questions incorrectly, review the appropriate text before proceeding.

REVIEW QUESTIONS

1. The five main parts of the telephone instrument are:
   a. ________
   b. ________
   c. ________
   d. ________
   e. ________

2. List the three main reasons for having an induction coil in the telephone instrument.
   a. ________
   b. ________
   c. ________

3. The basic ringer signal is pulsed at a________ cycles per second rate, regardless of the line carrier frequency.

4. The device used to protect the telephone from line surges is called an________.

5. The transmission line impedance used as a standard in telephone work is________ohms.

6. Line impedance may be held reasonably constant by using________coils at various points in the circuit.

7. For each of the coils listed below, indicate the number of windings usually available by placing an "X" in the appropriate column:

	Coil Type	1	2	3	4	5	6
a.	Retard coil						
b.	Induction coil						
c.	Repeating coil						
d.	Hybrid coil						

8. In the case of the system described, why are "dc supervisory signals" required? ________
____

9. Two frequently encountered types of telephone transmission lines are________pair and ________pair. (The latter in sheathed cables)

10. ________relays are sometimes used to discriminate against unwanted "rings" on party-line circuits through identification of the particular subcarrier pulsed at the basic ring frequency rate.

TELEPHONE SWITCHING

This session will discuss some of the techinques used in routing telephone calls to their destination.

Highlights:

- The Manual Switchboard
- Automatic Switching
  - The telephone dial
  - Tone dialing
  - Step-by-step switching
  - Panel switching
  - Crossbar switching
  - Electronic switching

THE MANUAL SWITCHBOARD

Examine the manual switchboard (Figure 2-3) and see how the connections described in the previous session are accomplished.

When the party on line 907 lifts the receiver, the indicator in Position 3, corresponding to the answering jack for 907, lights. The operator plugs the local headset into the answering jack. Subscriber 907 asks for 132. The operator takes the cord for 907 in Position 2 and connects it to the calling jack for 132 in Position 1 as shown by the heavy line of Figure 2-3. The indicator will remain lit at the answering jack as long as the originating phone is "off-hook". When the light goes out, the operator may remove the cord, freeing both lines for additional calls. When the operator connects 907 to 132, a key switch on the board enables the operator to ring 132. When 132 goes "off-hook" to answer, its indicator lights steadily, indicating an answer. The operator disconnects the headset while the subscribers carry on their conversation.

In this system, each operator has to service about 200 incoming lines (via answering jacks) and has access to about 10,000 "called" lines in three groups of 3,300 each (Positions 1, 2, 3).

AUTOMATIC SWITCHING SYSTEM

Telephone Dial

In an automatic switching system, some method of generating control signals is necessary. The telephone dial (Figure 2-4) provides this means. Essentially, the dial consists of two principal sets of contacts:

1. Disconnect line from handset while dialing.
2. Break line on dial pulse operation.

The telephone dial generates control signal pulses by opening and closing the connection to the telephone line in a timed sequence. The timing function and number of makes and breaks is the function of the dial. When you dial a number, a contact transfers to hold the line closed under control of the dial mechanism. When you release the dial, the spring (previously wound when digit value was selected) unwinds under the control of a "governor" permitting a baud wheel (like a CB cam) to cause the line contacts to open and close in a precisely timed manner. We will see how these pulses are used under "Step-by-Step Switching.

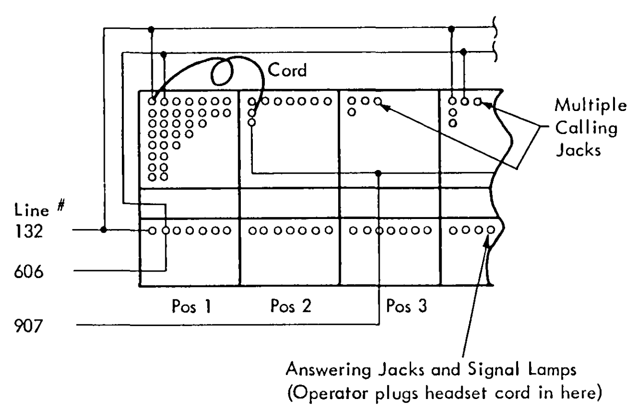


FIGURE 2-3. MANUAL TELEPHONE SWITCHBOARD

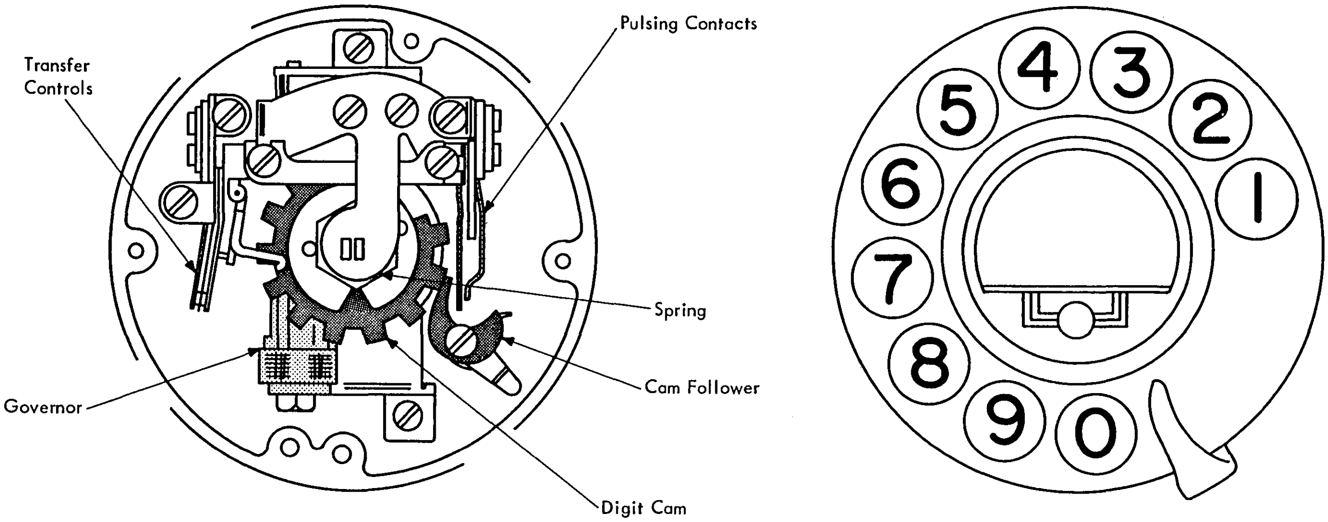


FIGURE 2-4. TELEPHONE DIAL

Tone Dialing

The normal manual dial still requires the "dc supervisory signals", but, if we do our signaling on-line with audio frequencies, the dc can be eliminated.

Tone dialing uses eight different frequencies, generated by a small transistor oscillator circuit in the subscriber telephone set. See Figure 2-5. Suppose you wanted to dial 4265. The depression of the "4" key would cause the generation and transmission of frequencies A2 and B1; similarly "2" key would yield A1 and B2, "6" produces A2 and B3,

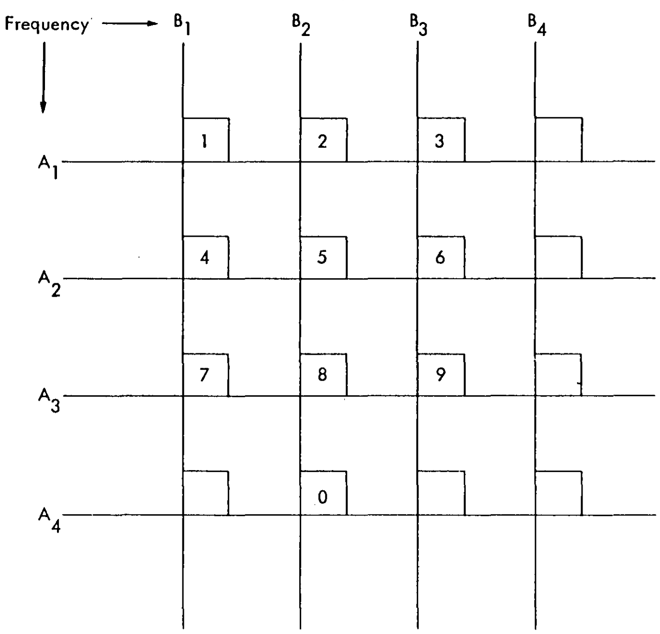


FIGURE 2-5. TONE DIALING DIGITS

and the result of keying a "5" is A2B2. At the central office, these audio-frequency signals would be decoded to produce impulses to control the required line switching equipment.

Step-by-Step Switching

One method of utilizing the dialing pulses to select the required telephone line is through a decoding system of rotary step selector relays (like the kind used for the IBM Collator Card Counting Device). See Figure 2-6. The example used is for dialing 881. The first digit dialed is an "8"; this produces eight pulses on the line at the prescribed rate. (If they were too fast, the relay could not count them all and you would get a wrong number; and if too slow, your first digit might cause two relays to step.) The first relay advances from 0 to 8, the second digit passes through contacts of #1 relay to cause the second relay to step from 0 to 8, and the third digit passes through contacts of #1 and #2 relays to cause #3 relay to advance from 0 to 1. The circuit is now complete; the called phone rings, communications are established. Note that this system requires the relays to hold their count throughout the period of connection. This procedure ties up much hardware for each call and limits the call-handling capacity of the office. The step-by-step system usually uses four-dial digits and can provide service to 9999 lines plus the "operator".

Panel Switching

Another step-type switching method utilizes motor-driven, rotary switch units called Panel Switching.

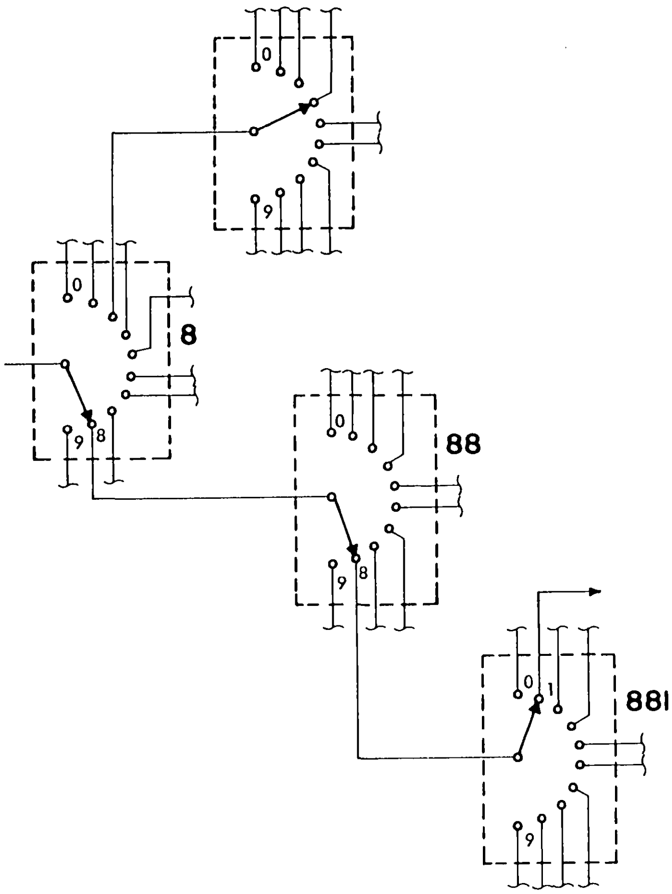


FIGURE 2-6. PRINCIPLE OF STEP-BY-STEP SWITCHING

Each bank of equipment usually controls 500 lines or circuits. This system has a high maintenance requirement because it is constantly searching for calls.

Crossbar Switching

A more recent type of switching is called Crossbar (Figure 2-7). This method controls only 200 circuits per section but has the advantage that once a circuit is established, the remainder of the unit is free to service other calls instead of being tied up for the entire call as in step-by-step switching. In Figure 2-7, a circuit is established as follows:

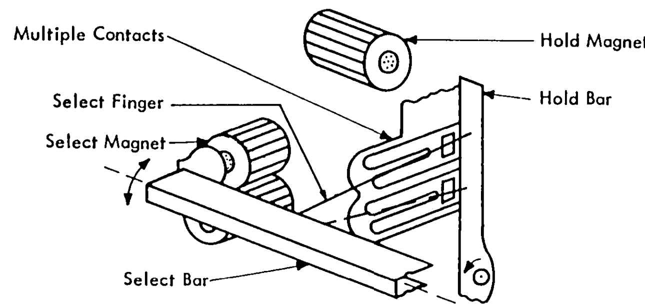


FIGURE 2-7. CROSSBAR SWITCHING

1. Select Magnet is energized.
2. Select Bar rotates.
3. Multiple Contact upper or lower makes with Select Finger (depends on which Select Magnet was energized).
4. Hold Magnet energizes.
5. Hold Bar operates, locking Select Finger into contact with proper Multiple Contact.
6. Select Magnet and Bar are now free to select other circuits.
7. Select Finger stays in contact with Multiple Contact and pivots at its point of attachment to the Select Bar.

Electronic Switching

Recently announced by the Bell System is an Electronic Switching System for telephone calls utilizing computer concepts in circuit selection and routing. Refer to the bibliography at the end of this publication for the source of more detailed information concerning this method.

The text for Session 2 is concluded. Answer the review questions and proceed to Session 3. If you answer any questions incorrectly, review the appropriate portions of the text before proceeding.

REVIEW QUESTIONS

1. How many subscribers can be served by a manual switchboard of the type discussed in the text?

2. The telephone dial provides dc________ to operate the relays or selectors of________, ________or________type switching systems.

3. Tone dialing eliminates the need for the______ ______________ ____________ of the older systems.

4. The frequencies transmitted to represent the digit "5" in tone dialing are: (Refer to Figure 2-5 to answer this question.)
   a. A1B1
   b. A1B2
   c. A2B2
   d. A3B4

5. Once a circuit is selected by the stepper relays in step-by-step switching, they must stay that way until the call is terminated. (True/False).

6. Crossbar switching releases the select bar to service other calls once the circuit is established. (True/False)?

7. Electronic switching employs________concepts in servicing the switching requirements of a telephone system.

LONG DISTANCE SYSTEMS

The facilities utilized in placing long distance phone calls are introduced in this session.

Highlights:

- Long distance systems
  - Direct Distance Dialing
  - Operator Distance Dialing
- Five classes of central offices
  - End
  - Toll
  - Primary Center
  - Sectional Center
  - Regional Center
- Purpose of Carrier Systems
- Maximum of seven links in a DDD call

You have examined the necessary equipment for local telephone communications and now are ready to cover a great distance on the "Long Lines" system. In long distance calling, two new terms are used: Direct Distance Dialing (DDD) and Operator Distance Dialing (OPD). DDD is performed directly by the switching system as a result of the Area code which is dialed, while OPD requires manual intervention, at least in part, by the telephone operator.

In this session you will encounter switching centers and equipment between the local office and the switching center. Look at Figure 2-8 and get oriented. There are five "classes" of telephone offices:

1. End
2. Toll (Center or Point)
3. Primary Center
4. Sectional Center
5. Regional Center

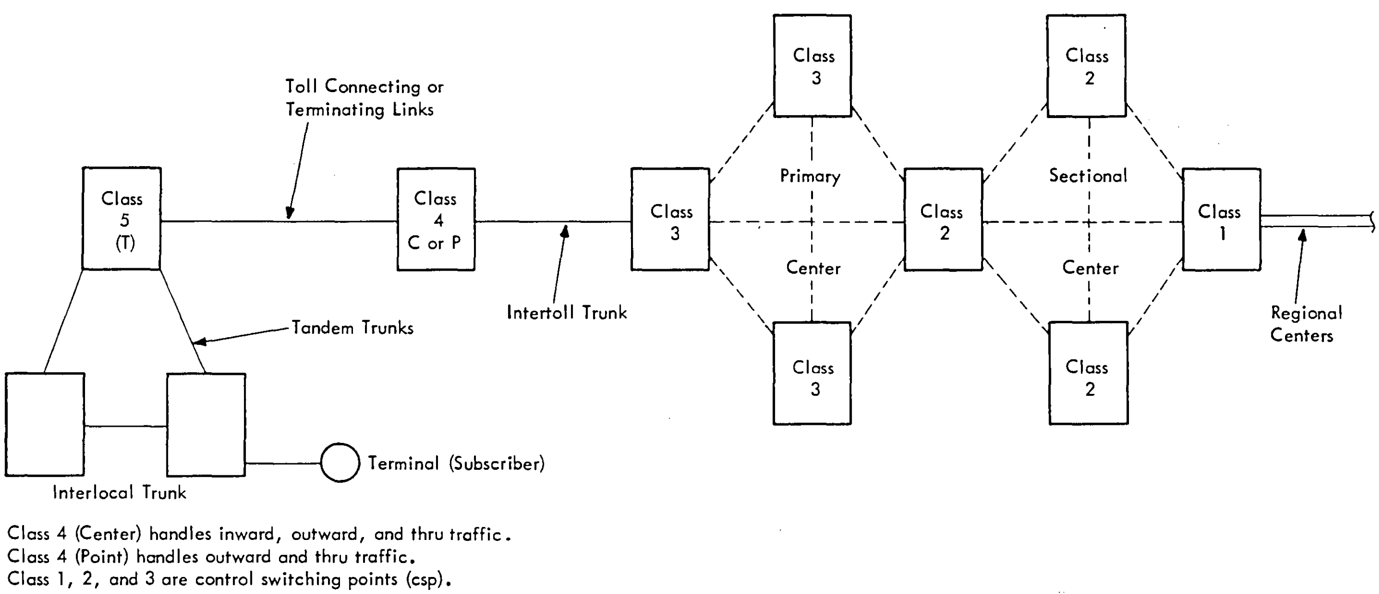


FIGURE 2-8. LONG LINES SYSTEM

End Office. If the area of service is small, a single Class 5 or End Office may service it. In larger, metropolitan areas, two or more End Offices may be required to service the subscribers in the area. These are called End Offices and the Class 5 office becomes a Class 5T (Tandem) Center Exchange. The End Offices are connected to the 5T Center Exchange through Tandem Trunks and to each other by Local or Interlocal Trunks.

Toll Office (Center or Point). End offices or 5T offices are connected to the Class 4 offices via Toll-connecting or terminating links. If the Class 4 office handles Inward, Outward, and Through traffic, it is a Toll Center (4C). If it only handles Outward and Through traffic, it is a Toll Point (4P). The latter class means that if operators are present at the office, they will not handle incoming traffic.

Primary Center. To service a particular area, several Toll Centers may be assigned as Primary Centers or Class 3 offices. These are connected for prime and alternate traffic routing as required by circuit loading.

Sectional and Regional Centers. Further, Class 3 centers route calls to the next larger function, the Class 2 Sectional Centers and finally to the Class 1 Regional Centers. Every pair of Regional Centers has direct interconnecting circuits.

Depending upon message-handling requirements, Carrier Systems employing various methods of multiplexing may be used to provide the interconnecting circuits or channels between centers. The Class 1, 2, and 3 offices are usually called Control Switching Points (CSP).

It is interesting to note that a DDD transcontinental telephone connection will not require more than seven links to complete the connections.

The text for Session 3 is concluded. If you can answer all of the review questions correctly, go on to Session 4. If you answer any questions incorrectly, review the appropriate sections of the text before proceeding.

REVIEW QUESTIONS

1. The abbreviation "DDD" stands for __________ __________ __________.

2. There are __________ classes of telephone offices in the long distance system.

3. The maximum number of "links" to complete a long distance transcontinental telephone call is __________.

4. Class 1, 2, and 3 offices are called __________ __________ __________.

5. A Class 3 office must route a call directly to a Class 2 office. (True/False)

6. All offices handle all types of traffic. (True/False) Why?

____

____

____

____

____

____

CHANNEL FACILITIES

Some of the methods employed for channelization of telephone facilities are presented in this session.

Highlights

- Open Wire lines
- Toll Cables
- Carrier Systems
  - C, N, L1, L3
- Grades of Channels
  - Telegraphic grade
  - Subvoice grade
  - Voice grade
  - Wideband (Telpak)

CHANNELS NECESSARY

In telephone work, the necessary circuits or channels for carrying out communication may be divided into three classifications:

1. Open Wire Lines
2. Toll Cables
3. Carrier Systems

In some areas, the previously described open wire lines are still in use. More modern systems employ the twisted-pair toll cables almost exclusively, even on a local basis.

Once a signal must be transferred between Control Switching Points, it is usually advantageous to employ Carrier Systems. Carrier Systems, through frequency division multiplexing, allow one pair of wires to carry multiple calls. The pair of wires may be: open wire, twisted pair, coaxial cable, or a microwave radio beam. Table 2-1 lists some of the available types of carrier systems. The Number of Circuits Derived column expresses the total capability of the system in terms of normal voice communication channels. If wider bandpass characteristics are needed, the number of circuits per system can be decreased to accommodate a wider band of frequencies; for example, the Type N Carrier System can provide 12 full-duplex voice channels through frequency division multiplexing on one carrier, or, its capabilities may be grouped to provide one circuit having a 48-kc bandwidth.

Refer to Figure 2-9 to examine how an L1 Carrier System performs. The initial channel is 4 kc wide (handling 200 to 3000 cps for voice-frequency signal). Twelve of the voice channels can be combined to form one Fundamental Group. Five Fundamental Groups representing 60 voice channels are then combined to form one Basic Supergroup. Ten Supergroups of 60 channels are combined to form the L1 configuration of 600 voice channel equivalents. Since each channel is 4 kc wide and there are 600 of them, we have a facility whose total capability would be employed to handle any transmission requiring a bandwidth of 2.4 mc (4 kc x 600 channels).

GRADES OF CHANNELS

Channels are divided by grades. Primarily, these are:

1. Telegraphic grade
2. Subvoice grade
3. Voice grade
4. Wideband

TABLE 2-1. CARRIER SYSTEMS AVAILABLE

Carrier System Type	Number of Circuits Derived	Transmission Facility
C (Telephone)	3FDX	4-Wire Open Line
N (TEL or PR)	12FDX	Non-Loaded Toll or Exchange Cables
L1 (TEL or PR)	600FDX	Paired Coax Cable
L3 (TEL or PR)	1860FDX	Paired Coax Cable

PR = Broadcast Program Use

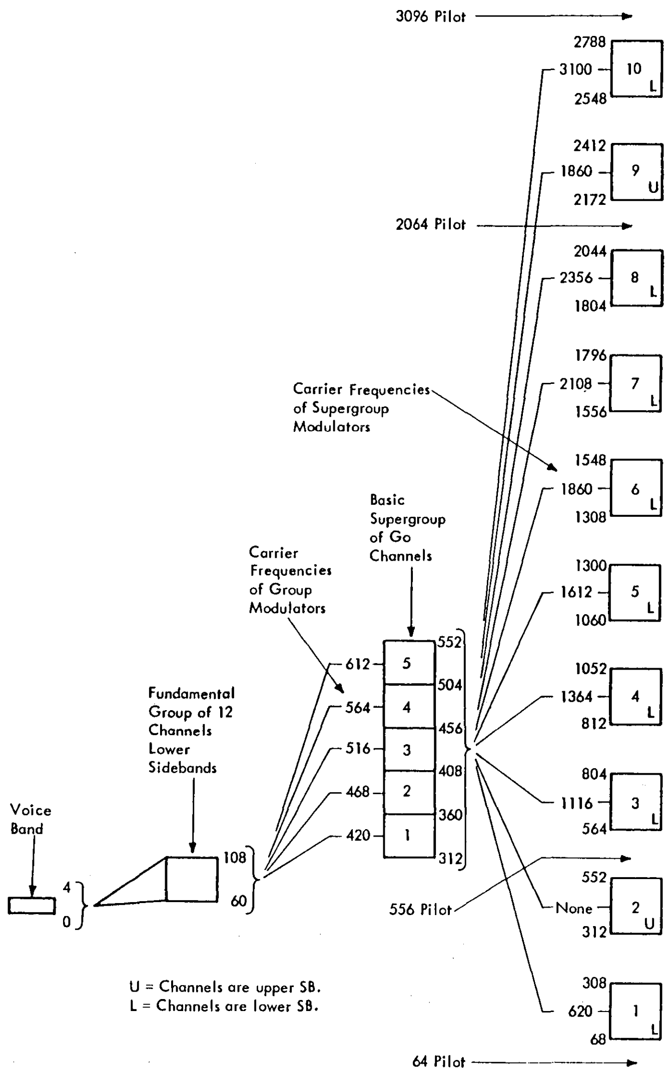


FIGURE 2-9. FREQUENCY TRANSLATION, L-1 CARRIER SYSTEM

Telegraphic grade channels have a narrow bandwidth (less than a voice channel) and can handle the telegraphic bit rates of the services of the first section of this course. Subvoice grade channels can be leased for data transmission at bit rates below 600 bps. Voice grade channels may be either dial-up or leased and may be used for voice communication or data transmission up to about 2400 bps. The exact data rate limit will depend on the type of modulation used. Wideband channels provide bandwidth for data transmission above 2400 bps and other services including radio programs, video, facsimile, and telemetry.

The Telpak services are examples of multi-use wideband channels. Telpak A is the equivalent of 12 voice circuits (like a Fundamental Group of the L1 Carrier System or a complete Type N Carrier System). Telpak A is 48 kc wide and therefore can handle either 12 simultaneous voice channels or about 48,000 bps of data transmission (with efficient modulation). Other capabilities of Telpak A include 40,800 bps of data transmission together with a voice communication coordinating channel (so operators may talk while data transmission is in progress)

Telpak B is a larger system, the equivalent of 24 voice channels. Telpak C provides 60 voice channels (like a Supergroup of the L1 System) or a 240-kc data channel. Telpak D provides 240 voice circuits or a single 960-kc bandwidth channel for data transmission.

From these specifications you can conclude that channel facilities are quite flexible in their assignment and cover almost any requirement for information handling whether it is voice or data.

The text for this session is concluded. If you can answer the following review questions correctly, go on to the next session. If you answer any questions incorrectly, you should review the appropriate portions of the text before proceeding.

REVIEW QUESTIONS

1. The three facilities with which we are concerned are:
   a. ____________________
   b. ____________________
   c. ____________________

2. When, by utilizing different carrier frequencies, one telephone line is capable of handling two or more calls simultaneously, channelization by frequency division________is being utilized.

3. The Type N Carrier Service can provide ________full-duplex voice channels or its capabilities may be lumped to provide one channel________kilocycles wide.

4. What is the bandwidth of the entire L3 carrier system if it is lumped as a single channel? ________.

5. The four grades of channels are:
   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________

6. Subvoice grade channels are usually employed for data transmission at less than________bps.

7. Telpak A compares in capacity with the type ________Carrier Service.

8. Telpak D provides the equivalent of________ voice channels.

9. ________channel facilities are usually used if data rates exceed 2400 bps

10. If you wished to transmit data at 230,000 bps, which Telpak service would be applicable?

CIRCUIT CHARACTERISTICS

Some of the problems encountered in telephone transmission are presented in this session.

Highlights:

- Attenuation (loss)
- Phase Distortion
- Noise
    - Crosstalk
    - White noise
    - Impulse noise

There are three main problems to be dealt with on a communication channel or line:

1. Attenuation (Loss)
2. Phase Delay or Distortion
3. Noise

Attenuation is the loss of signal power as the voice or data travels over the channel (Figure 2-10). Note that the amount of attenuation increases as the frequency of the signal increases. Two other factors affecting the signal loss are length and type of line. The longer the line is, the greater the loss. Some types of lines also have greater loss per unit length than others or perhaps different frequency response peculiar to that type of line.

In the same way that loss varies with frequency, the propagation rate of a signal on a line varies with frequency. This is called Phase Delay (Figure 2-11). The higher frequencies travel slower on the line than the low frequencies. This velocity difference is not usually troublesome when dealing with voice circuits but will create severe problems in data transmission.

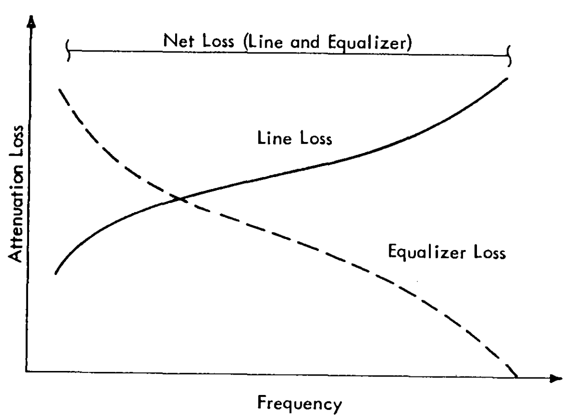


FIGURE 2-10. ATTENUATION

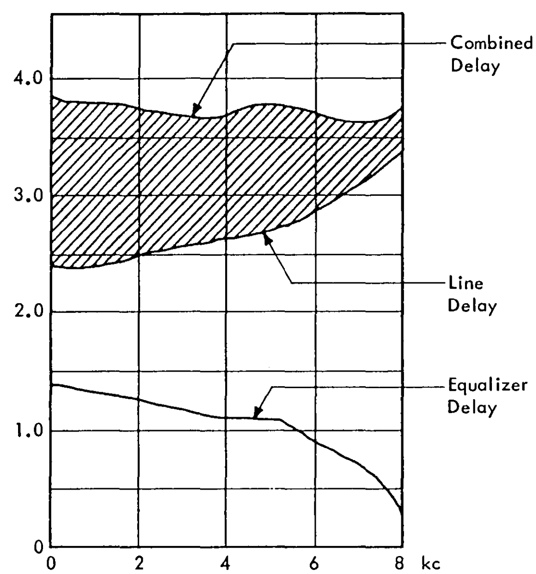


FIGURE 2-11. PHASE DELAY

Two approaches to this problem exist: either slowing down the "lows" or speeding up the "highs". Normally, the method used is to incorporate compensating circuits to slow down the "lows". For an example of compensation exhibiting these approaches, refer to Figure 2-12; this example could be compared to the tone control circuitry of an audio amplifier.

Noise encountered in telephone circuits is defined as any undesired signals on the line regardless of source or means of generation. In telephone work, noise is further classified as either Crosstalk or noise caused by external influences. Noise caused by external influences is also divided into two categories: White noise and Impulse noise.

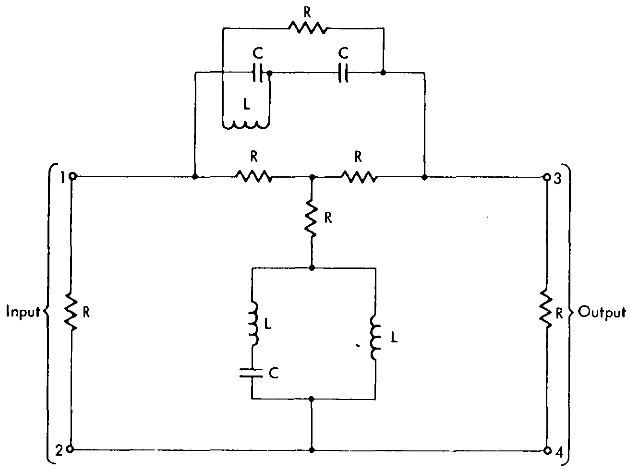


FIGURE 2-12. COMPENSATION

Crosstalk is a type of noise or interference created as a result of voice or data signals on one line being coupled into or induced in another line. Crosstalk is measured in units called Crosstalk Units, which express the voltage or current ratio of the disturbed circuit compared with the circuit causing the disturbance. Several factors affect the level of crosstalk:

1. Proximity of the circuits to each other.
2. Crosstalk increases with an increase in frequency.
3. Square wave fronts - and glitches - increase crosstalk.
4. Higher power levels accentuate crosstalk.
5. Weather conditions - particularly moisture - tend to increase the level of crosstalk.

Normal noise consists of White noise and Impulse noise. Noise is measured in noise units called "NU" or "dbrn". You will recall that the reference level for dbm is 0.001 watt; well, dbrn has a reference too. Dbrn is measured plus and minus with respect to a signal level of -90 dbm.

White noise (Figure 2-13) is a random background noise of relatively constant characteristics. While Impulse noise may be injected in any unpredictable manner, it cannot be characterized either in amplitude or frequency. Figure 2-14 shows White noise with some Impulse noise added. Spikes from inductive electrical machinery being turned on or off are examples of Impulse noise.

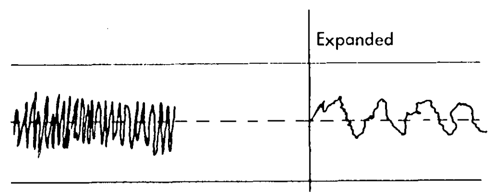


FIGURE 2-13. WHITE NOISE

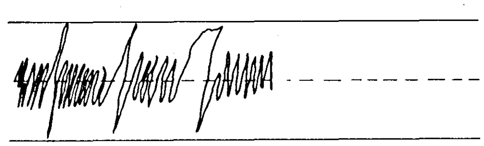


FIGURE 2-14. WHITE NOISE AND IMPULSE NOISE

The text for Session 5 is concluded. Answer the review questions and proceed to Session 6.

REVIEW QUESTIONS

1. Compare the results of normal loss or attenuation with those of phase delay if a signal alternates between sending 1000 cps and 3000 cps in equal 5-millisecond bursts.

2. Compensation is usually used to slow down the "lows" in order to eliminate the problem of _______ _______.

3. Three types of noise are considered as troublesome in telephone work. These types are:
   a.
   b.
   c.

4. Steep leading edges on signals tend to increase crosstalk. (True/False)

5. Widely varying power levels between signal elements tend to have no effect on crosstalk. (True/False)

6. If the weather is damp, crosstalk tends to (increase/decrease).

7. Frequency increasing or circuits being routed closer together tends to (increase/decrease) crosstalk.

8. Electromagnetic devices being turned on and off generate_________noise.

LINE EQUIPMENT

In this session, you will learn about some of the equipment used by the common carriers to overcome the problems presented in Session 5

Highlights:

- Repeaters
- Energy level diagram
- Hybrid coil and "Intersection loss"
- Echo Suppressor
- Line Transposition
- Compandor

In order to combat the problem of attenuation, it is necessary that the telephone company know where the attenuation is occurring and its magnitude. To determine this, they plot an energy level diagram of the line. See Figure 2-15, which shows the energy (power) levels in both directions along the line. The line schematic shows the various Repeaters used to boost the signal levels. Note that a signal cannot be allowed to deteriorate too much in power level before being amplified or the signal plus noise-to-noise ratio will suffer. The signal must be boosted before noise becomes an appreciable part of the signal plus noise value.

Repeaters are coupled to the line through the use of the hybrid coils. Some of the repeater types encountered on telephone lines are:

1. Type 21 - one-direction, two-wire line
2. Type 22 - two-direction, two-wire line
3. Type 44 - two-direction, four-wire line
4. Type V - two-direction, two-wire line

The Type 21 repeater will produce about 24-dbm gain, the 22 produces 18-dbm gain, and the Type V about 25-dbm gain. The Type 44 is similar to the Type 22 but is essentially a double version for four-wire lines.

Let's examine the basic concepts of Repeater operation by observing how a Type 21 is employed. (See Figure 2-16.) The transformer windings shown (numbered 1, 2, 3, 4, 5 and 6) are the six windings of a hybrid coil. The incoming line enters at terminals 4 and 9 and leaves by 6 and 7. At points 5 and 8 the amplifier is coupled into the line and the signal is boosted. The amplified signal is reinjected by winding 5 and adds to the signal on the line.

The amplifier element has a maximum gain of about 31 dbm, but the hybrid coil causes an "insertion loss" of about 7 dbm, resulting in a net gain of about 24 dbm. Note that the amplifier element cannot present a dc path form 5 of winding (1) of the hybrid to 8 of winding (3) of the hybrid or the "dc supervisory" path would be disrupted. Refer to Figure 2-17 to see how this problem is eliminated.

In Figure 2-17, capacitor C1 in the primary of input transformer T1 provides a complete circuit for the signals on the line, while effectively isolating the two sides of the line for dc. The output of the plate circuit of the amplifier is coupled to the line by winding (5) of the hybrid which serves as the anode load for the amplifier as well as an impedance matching device.

When signals are transmitted over long lines, the compounding of impedance mismatches through the link results in incomplete dissipation of the signal power at the termination. The power which is not absorbed by the load is reflected back on the line, out of phase with the main signal. To the originating end of the transmission this reflection appears as an Echo. The echo problem is annoying on "talk" circuits. It may cause errors in data circuits. The telephone company inserts devices called Echo Suppressors in the line to overcome this problem. See Figure 2-18.

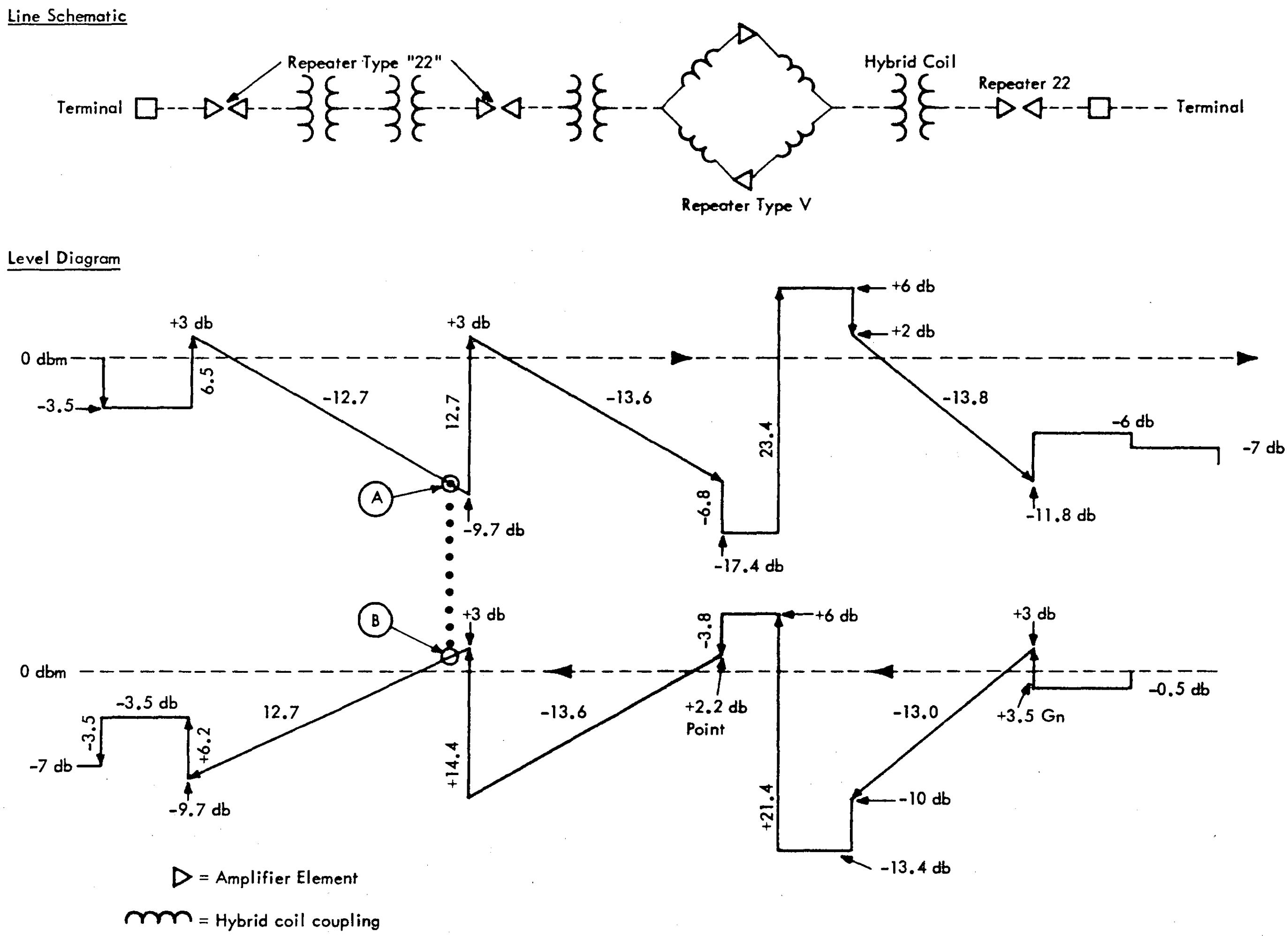


FIGURE 2-15. TELEPHONE LINE, ENERGY LEVEL DIAGRAM

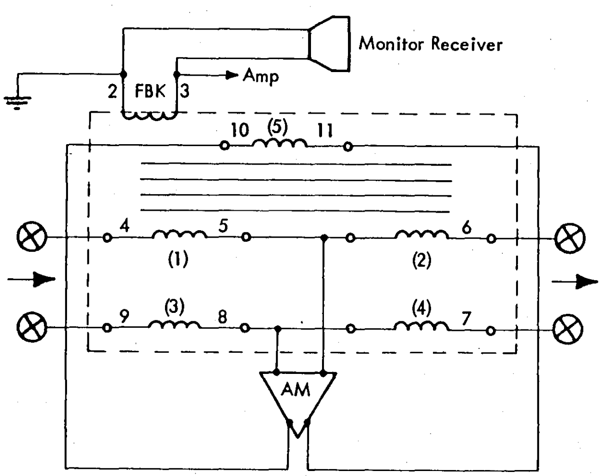


FIGURE 2-16. SIMPLE TWO-WIRE REPEATER

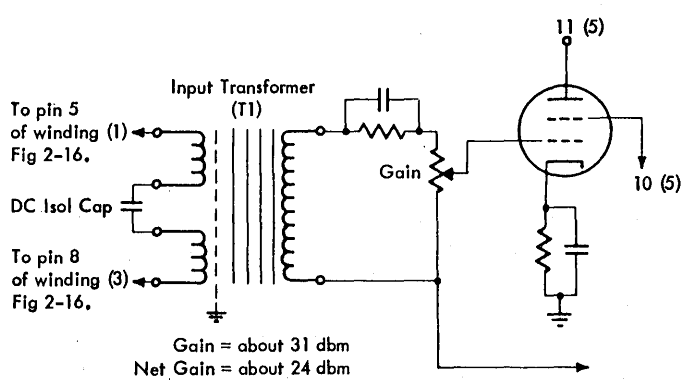


FIGURE 2-17. REPEATER AMPLIFIER CIRCUIT

If the desired transmission is from Station A to Station B, a return path echo from B to A would exist. The "direction detection" circuit can sense the originating end of the transmission and, when a signal tries to pass in the opposite direction (without an inactive period sufficient to allow the suppressor to drop out and check originating end again), the hybrid circuit will introduce a 40-dbm loss to the signal in the reverse direction while only causing a 2-dbm insertion loss in the forward direction.

One problem encountered in data circuits utilizing echo suppressors is "turn-around " time (the time it takes the echo suppressor to decondition, from allowing transmission in one direction until it is ready to accept transmission in the opposite direction). This problem manifests itself in two ways. In the first case, if the suppressor "drops out" too fast, the echoes on line may not yet have decayed sufficiently to avoid interference. In the second case, if the echo suppressor is slow to "drop out", the first data bit or bits may be last. Some data circuits provide signals to intentionally disable echo suppressors (usually a 2025-cps signal).

Three approaches are significant in minimizing noise effects:

1. Line Balancing
2. Line Transposition
3. Compandor

If the relative impedances of both sides of a line to ground are not the same, noise susceptibility is increased. By careful attention to matched loading coils and careful splicing of conductors, the impedance of both sides of the line may be "balanced".

Because coupling between telephone lines and power lines is predominantly inductive, a method of canceling noise effect may be employed similar to that used to eliminate select noise on memory sense lines. This method is called Line Transposition (Figure 2-19). Since the wavelengths at power line frequencies are long, rather infrequent transpositions are usually based on an "eight-pole span" of wires. In addition, the pairs must be transposed relative to each other to minimize mutual coupling. If the open wire lines are operating in Carrier Service, more frequent transpositions are necessary due to the shorter wavelengths (140 kc = about 215 meters). This requires a secondary transposition pattern for use between "eight-pole spans".

One method of avoiding crosstalk is to maintain a reasonably narrow range of signal levels on the line. The equipment used for this purpose is called a Compandor (Figure 2-20). The signals on the line for a conversation may range in level from -50 dbm to +10 dbm. The complex waveshapes of voice frequencies present steep wave fronts which look like higher frequencies. By using the Compandor, a signal level coming from the subscriber over a 60-dbm range can be compressed to a 30-dbm range on the line and expanded back to a 60-dbm dynamic range at the load or terminating end. The name Compandor is a contraction of compressor and expandor; it compresses signal levels on the sending end and expands them on the terminating end.

You have now examined the important parts of a telephone system as used for voice communication, together with a few hints toward its use in handling data. In the following sessions, you will learn more specifically how these items are associated with data transmission.

The text for this session is concluded. If you can answer all of the following review questions correctly, proceed to the next session. If you answer any questions incorrectly, review the appropriate text before continuing.

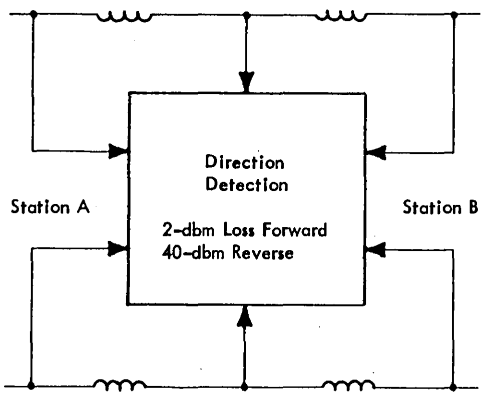


FIGURE 2-18. PRINCIPLE OF ECHO SUPPRESSION

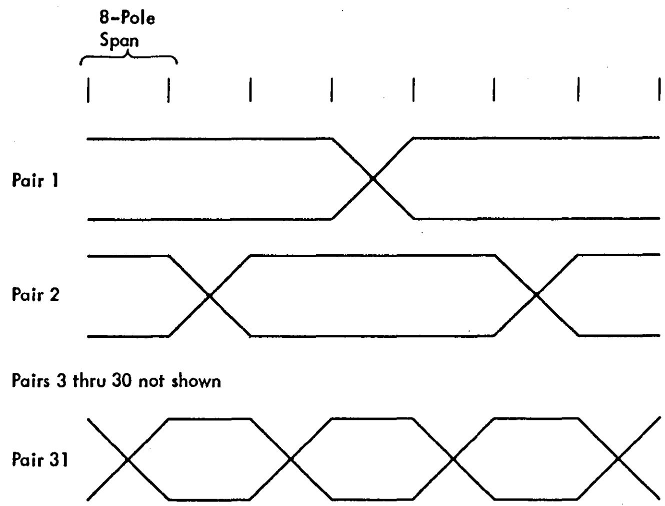


FIGURE 2-19. LINE TRANSPOSITION

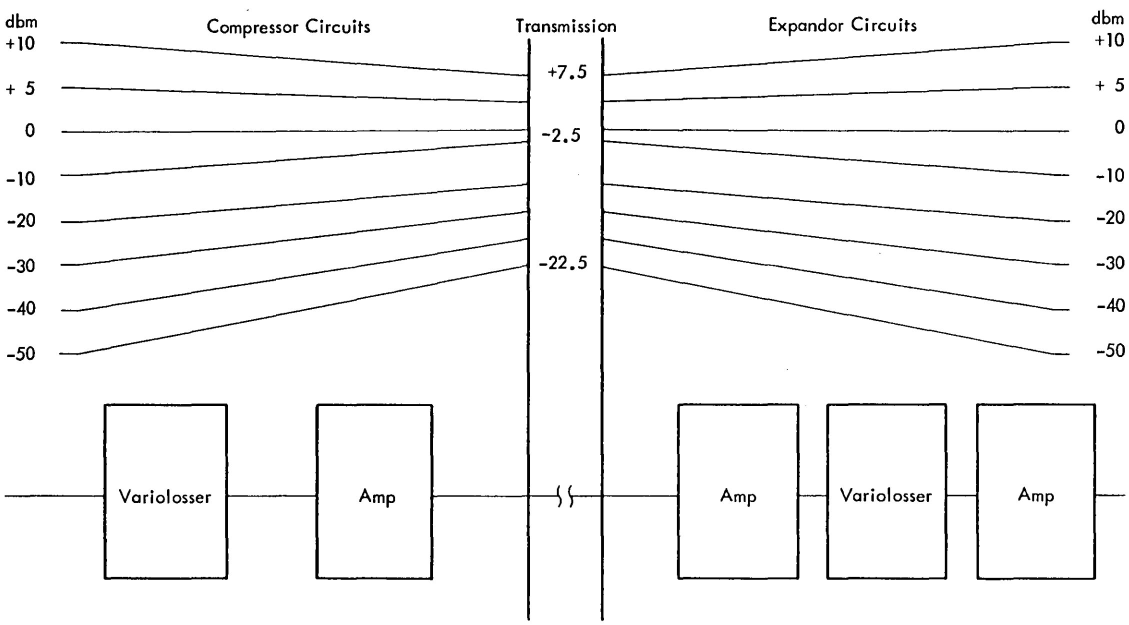


FIGURE 2-20. COMPANDOR OPERATION

REVIEW QUESTIONS

1. The device used to overcome normal attenuation is the________, which is coupled to the line through a________coil.

2. If all of the power in a signal is not absorbed, ________develop on the line.

3. Turn-around time of a line is primarily determined by the time required for the__________ ________in the line to change their directional characteristics.

4. Repeaters amplify noise as well as signal. (True/False).

5. If a repeater is overdriven, the signal will be distorted just as turning the volume control too high on a record player causes distortion. If a "bus-back" (direct interconnection) were provided between the outgoing line of Figure 2-15 to the incoming line at points (A) and (B) respectively, would "overdrive" result?

____
____
____
____
____
____
____
____

6. What component in Figure 2-17 prevents shorting the "dc" supervisory" circuit of the line?

7. Line balancing as an aid in eliminating noise requires that care must be taken in splicing and selection of loading coils to insure the same________in both sides of the line.

8. The device used to control the maximum and minimum signal excursions on the line is called a________.

9. Line transposition is used to help eliminate ________.

DATA TRANSMISSION

This session begins to consider the use of the telephone system as a means of handling data other than voice signals.

Highlights:

- Asynchronous (Start - Stop) terminals
- COAM equipment
- Schedules and classes of all grades of channels
- Data Set availability

Asynchronous communication will be used with the following IBM terminal equipment:

IBM 1030 Data Collection System
IBM 1050 Data Communication System
IBM 1060 Data Communication System
IBM 1070 Process Communication System
IBM 2701 Data Adapter Unit
IBM 2702 Transmission Control
IBM 2703 Transmission Control
IBM 2712 Remote Multiplexor
IBM 7740 Communication Control System, and
Many special purpose teleprocessing terminals.

In addition to the IBM terminals used, the following will be required:

1. Common carrier telephone lines.
2. Common carrier data sets.
3. Customer-owned lines and data sets.
4. IBM Line Adapters

Customer-owned equipment, as well as IBM terminal devices, are classed as COAM equipment by the telephone company. COAM stands for Customer Owned And Maintained.

Common carrier telephone lines are further divided as either dial-up or leased. Dial-up lines are available on an "as required" basis. Leased lines are further divided into "Schedules" (1, 2, 3, and 4) by AT & T. Schedule 1, 2, and 3 lines are for telegraphic type signaling and correspond to 60, 75, and 100 wpm circuits respectively. Schedule 4 lines include the voice and subvoice grades and are further subdivided as 4, 4A, or 4B. Each of the subdivisions carries with it specific amounts of defined phase delay and frequency response characteristics. The Schedule 4A and 4B lines may also be "conditioned" (at additional cost), meaning that they have been carefully selected to minimize delay, distortion, loss, echo, and interference. Schedule 4 lines are available on a 24 hours a day, 7 days a week bias.

Western Union grades its lines differently. First, all Western Union channels may be assigned for SPX, HDX, or FDX operation. Class A channels are suitable for binary transmission up to 50 bps; Class B channels, up to 57 bps; Class C channels, up to 75 bps; Class D channels, up to 180 bps; and Class E and F channels for higher rates.

Class E channels have a characteristic definition similar to that of AT&T's Schedule 4, type 4A. Class F channels do not compare exactly with Schedule 4; their complete specification is as follows:

Envelope delay (Phase delay) between 800 and 2700 cps is less than 1 millisecond.
The difference in loss (attenuation) between 800 and 2700 cps does not exceed ± 3 db relative to a reference frequency of 1600 cps.

The use of the channels discussed thus far is limited to data transmission requiring bandwidths in the voice or subvoice region. Primarily, this means less than 3000 bps. For higher data rates, wideband channels are available such as Telpaks A, B, C, and D. In some cases, data transmission will be over lines owned by the customer. If telegraphic grade channels are used for data transmission, the business machine (terminal) must usually be equipped with a relay type interface to accept the current mode signals of that class.

When data rates requiring subvoice, voice grade, or wideband channels are to be processed, the terminal must be matched to the communication channel with a data set. Remember that the function of

the data set is to convert the data stream from the terminal device into a form acceptable to the channel when sending and the reverse when receiving.

Data sets may be provided by the customer, by IBM, or by the common carrier. One type of data set provided by IBM in the United States is the IBM Line Adapter (Modem). The Modem is available in four basic types: less than 4.75 miles, less than 8.25 miles, unlimited distance, and shared. ("Shared" means two or more sets of line adapters can operate simultaneously on the same line by using different subchannel carriers.) These types will be covered in detail later. If customer-owned lines are to be used with the IBM Line Adapter, preinstallation testing should have been performed by the IBM Area Line Specialist.

The text for this session is concluded. If you can answer the following review questions correctly, proceed to the next session. If you answer any questions incorrectly, review the appropriate portions of the text before proceeding.

REVIEW QUESTIONS

1. The abbreviation COAM stands for ________ ________ ________ ________.

2. Schedule 1, 2, and 3 lines from the telephone company or Telegraph Class A, B, and C channels respectively are used for signalling at ________, ________, and ________ words per minute rates.

3. Schedule 4 lines are subdivided into type ________, ________, ________.

4. The IBM equivalent of a data set is the IBM ________ ________.

5. If transmission of data involves bit rates exceeding 3000 per second, ________ type channels are usually required.

6. If telegraphic grade channels are utilized, the data terminal must be provided with a ______ type interface.

7. The function of a data set is ________________ ________________________________ ________________________________.

INTERFACING DATA TERMINALS AND COMMUNICATION FACILITIES

This session reviews the basic data set and the Recommended Standards for interfacing to terminal equipment.

Highlights:

- Review of basic data set
- Electronics Industries Association Recommended Standards 232 and 232A
  - Line names
  - Connector pin assignments
  - Signal levels
  - Conventions of state
  - Clocking

GENERAL REQUIREMENTS

Before going into detail concerning a specific data set, let's establish the general requirements for the following:

1. Characteristics of interface between terminal and data set.
2. Operational modes of the data set.
3. Line signal characteristics of data sets.
4. Special optional features.

The characteristics of the interface between the terminal and the data set have been established by the EIA (Electronics Industries Association) through work with communications companies and manufacturers of terminal equipment. Outside the United States, a similar set of agreed standards have been developed by the ICCTT (The International Consultative Committee on Telephone and Telegraph). Every line of the interface has not been defined, but those significant to basic operations have been defined. The lines which are undefined, but for which connector pins are available, may be utilized by mutual agreement of the terminal manufacturer and the data set manufacturer.

For purposes of this course, we will examine Recommended Standards 232-A of the EIA, together with the principal differences between RS-232 and RS-232-A, since we have machines utilizing both. Another interface, known as the "Digital" interface, is used for high-speed, wideband data sets. This interface will be discussed in Section 3, Synchronous Data Communication.

Operational modes of the Data Set include:

1. HDX operation on two-wire line.
2. FDX operation on two-wire line.
3. HDX operation on four-wire line.
4. FDX operation on four-wire line
5. Special considerations in the case of parallel bit transmission.

The line signal characteristics of the data sets to be covered in these operational modes are Frequency Modulation by frequency shifting, frequently called frequency shift keying or FSK. The frequencies involved will be covered under the applicable data set.

REVIEW OF BASIC DATA SET

The basic data set was described in Introduction to Teleprocessing. At this point we will briefly review the concepts presented in that document. Refer to Figure 2-21 and examine the seven basic lines:

1. Request to Send - Conditioning this line activates the "modulator" portion of the data set.
2. Clear to Send - When the modulator is fully active and ready for data, this line will become active.
3. Send Data - When Request to Send has been issued, and acknowledged by Clear to Send, the Send Data line presents the serial binary data bits to the data set in the form of rectangular pulses.
4. Received Data - This line, when the data set is receiving, delivers rectangular data pulses

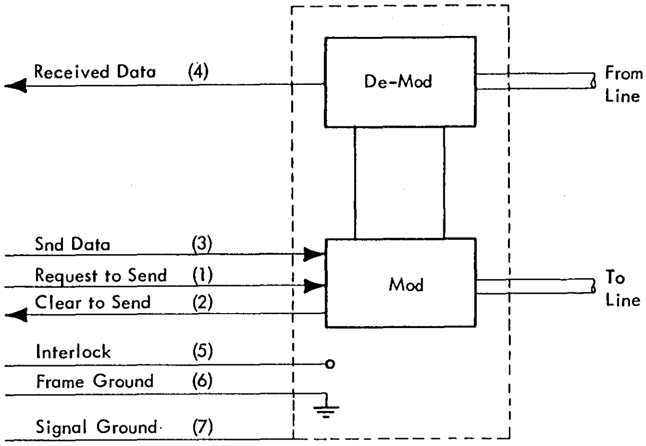


FIGURE 2-21. BASIC DATA SET

to the terminal device. These signals are the result of demodulating the line signal.

5. Interlock - Signals proper power-on and operational status between terminal and data set.
6. Frame Ground - Protective ground for data set (power).
7. Signal Ground - Reference signal level of exchanged data signals.

The data set may be divided into five functional areas (Figure 2-22):

1. Control
2. Modulation
3. Carrier Generator
4. Demodulator
5. Shaper Circuits

The Control circuits embody the functions of Request to Send, Clear to Send, and Interlock (plus options).

The Modulation circuits provide the means of varying the signal of the Carrier Generator to represent the serial binary data on the line.

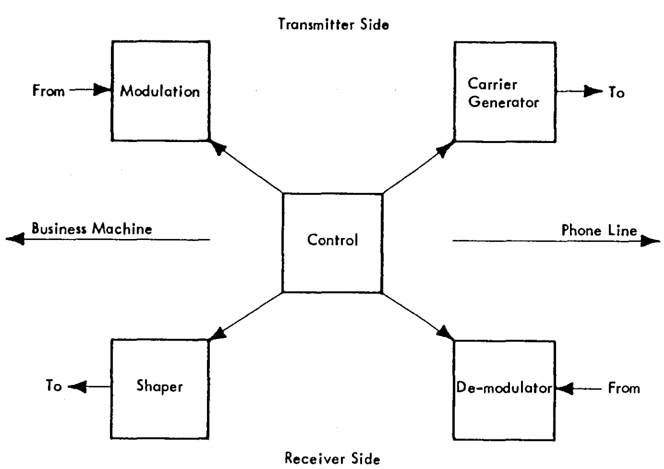


FIGURE 2-22. DATA SET

The Demodulator contains the necessary circuits to detect the presence of a received signal, to make sure it is at least at "Threshold" signal strength, to develop automatic (or manual) gain control voltages, and to deliver a train of pulses to the Shaper corresponding to the remote "Send Data".

The Shaper circuits take the poor quality waveform of the demodulator output and form it into rectangular pulses to be delivered to the terminal on the Received Data line.

RECOMMENDED STANDARD 232A of EIA

The following information is based on the October 1963 issue of EIA Standard RS-232-A, entitled: "Interface Between Data Processing Terminal Equipment and Data Communication Equipment"

Line of Demarcation

The line of demarcation is the signal interchange point between the terminal and the data set. In most of our applications, this is the 25-pin connector located at the rear of the data set. The pin assignments for each of the interface lines are listed in Table 2-2. Table 2-3 shows the conventions required in referring to line and signal states.

Voltage Levels and Circuits

Circuit AA - Protective ground: Bonded to machine frame and to external ground in addition, if required by local regulations.

Circuit AB - Signal ground: Common ground reference for all interface circuits except AA.

Circuit BA - Transmitted Data: The binary data to be transmitted is to be delivered on this circuit. A voltage level from +5 to +25 volts represents a Space, while -5 to -25 volts represents a Mark. The voltage level must be held for the complete desired length of the bit. When no data is being transferred, this line should be held at Mark level (includes between characters as well as idle line time).

NOTE: Rectangular waveforms with good edges should be delivered by the data terminal to circuit BA.

Circuit BB - Received Data: This line delivers rectangular waveforms to the data terminal. A Mark level is -3 to -25 volts; space level is +3 to +25 volts. These waveforms have a duration equal to the bit time. In receive mode, the data set should hold this line marking during inactive periods (unless option of Space Hold is installed).

TABLE 2-2. PIN ASSIGNMENTS FOR INTERFACE LINES

Pin Number	Circuit	Description
1	AA	Protective Ground
2	BA	Transmitted Data
3	BB	Received Data
4	CA	Request to Send
5	CB	Clear to Send
6	CC	Data Set Ready
7	AB	Signal Ground
8	CF	Data Carrier Detector
9 }	--	Reserved for data set testing. These two
10 }	--	pins shall not be wired in the data processing terminal equipment.
11	--	Unassigned
12	--	Unassigned
13	--	Unassigned
14	--	Unassigned
15	DB	Transmitter Signal Element Timing (Data Communication Equipment Source)
16	--	Unassigned
17	DD	Receiver Signal Element Timing (Data Communication Equipment Source)
18	--	Unassigned
19	--	Unassigned
20	CD	Data Terminal Ready
21	--	Unassigned
22	CE	Ring Indicator
23	--	Unassigned
24	DA	Transmitter Signal Element Timing (Data Processing Terminal Equipment Source)
25	--	Unassigned

Unassigned: These circuits may be assigned by mutual agreement of the parties on both sides of the interface.

TABLE 2-3. CONVENTIONS

Binary State	One	Zero
Signal Condition	Mark	Space
Voltage	Negative	Positive
Control Function	Off	On

Circuit CA - Request to Send: When a positive voltage is applied to this lead, it is On. A negative voltage turns it Off. As long as Request to Send is On, the carrier should be generated. As long as Request to Send (CA), Clear to Send (CB), and Data Set Ready (CC) are On, the data set should transmit the data presented on the Transmitted Data (BA) lead.

Circuit CB - Clear to Send: The On condition (positive) is the positive response of the data set to Request to Send. The On condition of CB will be delayed from the On condition of CA as required by the communication facility; however, when CA goes Off, CB shall go Off.

Circuit CC - Data Set Ready: Indicates data set is ready to operate. Test condition, alternate communication use, or "on-hook" should cause the Off (negative) condition of this line. This line in no way indicates that channel establishment with a remote location has been accomplished.

Circuit CD - Data Terminal Ready: The On condition of this line (positive) signals that the data terminal is ready for operation and, if other conditions as outlined under CC are met, the data set will be switched to Data mode (as opposed to Talk or Idle) and operation may begin. The data terminal may turn On CD in response to a ring signal on circuit CE. If the line is switched to Talk, or if the data terminal goes into an alternate use, or if the line goes "on-hook", circuit CD should go Off. The Off condition of CD does not inpair or disable the operation of circuit CE - the Ring Indicator.

Circuit CE - Ring Indicator: goes On (+) to indicate that a ringing signal is on the line.

Circuit CF - Data Carrier Detector: Goes On (+) to indicate that a carrier is being received from the remote data set. In some HDX services, may indicate operation of own carrier on Transmit as well as remote carrier on Receive. (Provided local copy is being provided.) There will be a time delay from loss of carrier until CF goes Off.

Circuit CG - Data Modulation Detector: Detects threshold of received signal level. If incoming signal is below threshold, CG goes Off (-).

Circuit CH - Speed Selector: On (+) condition signals high-speed range if data set has more than one. Signal is generated by data terminal.

Circuit CI - Speed Selector: On (+) condition signals high-speed range but is generated by data set.

Circuit DA - Transmitter Signal Element Timing: Clock signal from data terminal, if used. On and Off shall be 1:1 ratio and transition from On to Off shall occur at the center of each signal element on circuit BA (Transmitted Data). See Figure 2-23.

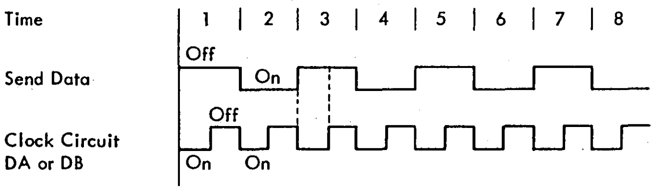


FIGURE 2-23. TRANSMIT CLOCK

Circuit DB - Transmitted Signal Element Training: Clock signal from data set. Transitions on Transmitted Data should occur at transition from Off to On (positive swing) of DB. See Figure 2-23.

Circuit DC - Receiver Signal Element Timing: Receive clock from data terminal. Transition from On to Off (plus to minus) indicates center of each signal element on circuit BB (Received Data). See Figure 2-24.

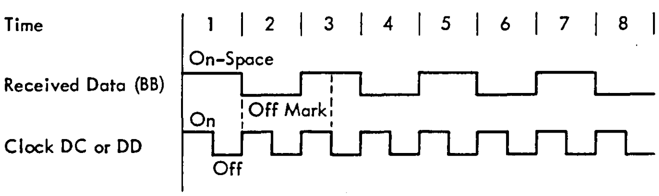


FIGURE 2-24. RECEIVE CLOCK

Circuit DD - Receiver Signal Element Timing: Receive clock, but provided by data set instead of data terminal.

Some systems require additional interface lines for error control or other purposes. EIA recommends that these lines have the word "Supervisory" added to their line names. Additional special lines may be established by mutual agreement. These will be explained where necessary.

Some of the lines on which voltage signals are specified in RS-232-A were classed as contact closure lines under RS-232. These will be further clarified when we discuss data sets in which they are applicable. Many IBM terminals are designed to work with the older RS-232 interface rather than RS-232A. The terms "Send Data" and "Transmitted Data" are used interchangeably.

Other Specifications

The EIA standard also contains specifications regarding the following:

1. Source and load impedances.
2. Source and load capacitance.
3. Rise and fall times of signals.
4. Resistance of circuits.
5. Variations for special applications together with cautions for designers.

For more detail concerning these items, refer to the bibliography for this course which tells how to obtain copies of the EIA RS-232-A.

The text portion of this session is concluded. If you can answer the review questions correctly, go on to the next session. If you answer any questions incorrectly, you should review the appropriate portions of the text before proceeding.

REVIEW QUESTIONS

1. The international counterpart of the EIA (Electronic Industries Association) is______ ____.

2. The two EIA standards utilized by IBM data terminals are________ and________.

3. List the names of the basic data set lines, excluding "grounds":
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________

4. Which of the above lines are associated with the demodulator portion of the data set?

   ____

5. What does Interlock On signal to the data terminal?

   ____
   ____

SESSION 9

DATA SET - IBM LINE ADAPTERS

This session will familiarize the reader with the "on-line" operation of the IBM Line Adapter in its role as a data set.

Highlights:

- Characteristics
  - Packaging
  - Speed of data handling
  - Modulation method-FSK
- Transmit Operation
- Receive Operation
- Waveforms - "on-line"

For purposes of explanation and categorization, Western Electric data sets are used as representative samples in this portion of the course. Data sets of other manufacturers providing equivalent performance will be encountered. Western Union, General Electric, and Lenkurt are some other suppliers of data sets. As an introduction to data sets, the IBM Line Adapters (Modems) will be explained, followed, in later sessions, by the Western Electric 103, 202, 400, and 800 families of data sets. These represent serial low speed, serial medium speed, parallel, and automatic calling types of data sets.

GENERAL CHARACTERISTICS

As explained previously, there are four basic types of IBM Line Adapters:

1. For use where total line length is less than 4.75 miles.
2. For use where total line length is less than 8.25 miles.
3. For use with unlimited length leased lines.
4. Shared usage; i.e., four modems operating on one line, simultaneously through Frequency Division Multiplexing.

Various IBM Line Adapters are packaged in SMS and SLT logic and designed for 150-bps or 600-bps transmission. They have one thing in common. They are all frequency-modulated (by FSK). This means a Mark is represented on the communications line by one frequency, while a Space is represented by a different frequency. IBM Line Adapters are used on customer installed/owned transmission lines, including complete communication networks with common carrier lines. Use on common carrier lines is restricted by various tariffs and regulations so that IBM Line Adapters may only be used on leased lines and then only if the entire system uses IBM Line Adapters. IBM Line Adapters and common carrier data sets cannot be mixed on the same circuit.

Refer to Table 2-4 for a comparison of the significant characteristics of the various types of IBM Line Adapters.

LIMITED DISTANCE ADAPTER TYPE 2B

We will examine one version of the IBM Line Adapter in detail to better understand common carrier data sets. The example chosen is the IBM Limited Distance Adapter Type 2B as block diagrammed in Figure 2-25. This Line Adapter is intended for HDX (half-duplex) operation on two-wire lines by utilizing a Mark frequency of 1000 cps and a Space frequency of 2200 cps for a total frequency shift of 1200 cps.

Transmit Operation

Let's examine the transmitter portion first. When the Send Request line is turned On, the high-low frequency modulator begins generating a type of sawtooth signal at 1000 cps which is fed to the filter circuit. The filter converts it to a sine wave signal before delivering it to the line via the line driver and its coupling transformer.

TABLE 2-4. COMPARISON OF IBM LINE ADAPTERS

Class	Type	Mark Frequency	Space Frequency	Packaging	2 or 4 Wire	Bit Speed	Xmit Level (dbm)	Rcv Min Level (dbm)
Limited	1A	1170	1830	SMS/SLT	2	134.49	-8	-15.5
Distance	1B	1170	1830	SMS/SLT	4	134.49	-8	-15.5
	2A	1000	2200	SMS	2	600	0, -6, -8	-21 to -27
	2B	1000	2200	SMS/SLT	2	600	0, -6, -8	-21 to -27
Leased	1A	1400	2600	SMS/SLT	2	600	0, -6, -8	-26 to -32
Line	1B	1400	2000	SMS/SLT	4	600	0, -6, -8	-26 to -32
Shared Line	$1A_x$	(below)	(below)	SMS/SLT	2	180	-8, -11, -14	-38
Adapter	$1B_x$	(below)	(below)	SMS/SLT	4	180	-8, -11, -14	-38
	x = Sub Chan							
	1	820	990					
	2	1230	1400					
	3	1640	1810					
	4	2050	2220					

NOTE: For more detailed information refer to IBM Line Adapter Units, Form 225-3473.

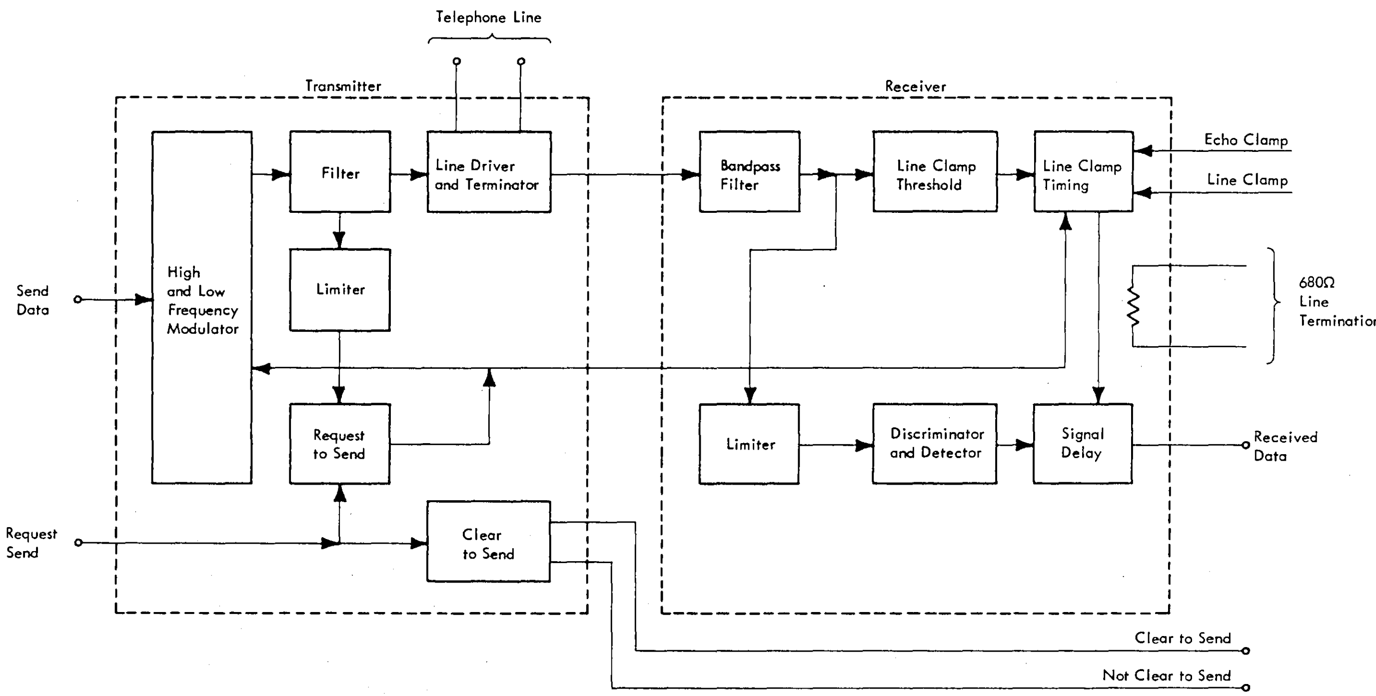


FIGURE 2-25. IBM LIMITED DISTANCE ADAPTER, TYPE 2B

After a 12.5-ms delay, the line Clear to Send turns On. Data delivered to the high-low frequency modulator will now cause generation of basic frequency waves at 1000 cps for Mark and 2200 cps for Space. These will be converted to sine waves and delivered to the communication line via the line driver and matching transformer.

During this operation, the Send Request line must remain On. When Send Request goes Off, the Modem is in receive mode.

Receive Operation

In receive operation, the signal from the line is coupled, through the same matching transformer used on transmit, to the limiter and the line clamp threshold circuit. If the input signal level falls below -21 to -27 dbm (See Table 2-4), the Received data line will not respond to line signals but will be clamped at a Mark level (negative).

The bandpass filter removes noise signals and distortion or sideband frequencies above and below the 1000- to 2200-cycle band.

The limiter circuit provides high gain to weak signals and low gain to strong signals, thus eliminating amplitude variations in the signal. This introduces amplitude distortion, but since the intelligence is contained in the frequency variation of the signal, we are assured of having a uniform amplitude input to the discriminator. This will assure that any variation in the output signal level is caused by a frequency variation (Mark or Space).

The signal delay circuit provides the necessary delay to the discriminator output to assure that the line clamp signal is responding to the same time interval of the signal.

The line clamp timing circuit will force the Received data line to a Mark level under four different conditions:

1. Input signal below "threshold" (less than -21 to -27 dbm or no signal at all).
2. Chopped up input signal.
3. Holds for 3 milliseconds after modulator is deactivated at fall of Send Request (while line echoes delay).
4. Echo clamp interface line is at a Mark level.

NOTE: The signal delay circuit also shapes the output of the discriminator to be sure that a uniform bit length is developed on the Received Data line. The Line Clamp signal from the line clamp timing circuit corresponds to a Data Carrier Detector function. For an analysis of the timing and signals characteristic of IBM Line Adapters, refer to Figure 2-26.

The text for this session is concluded. If you can answer all review questions, proceed to the next session. If you answer any questions incorrectly, review the appropriate portions of the text before proceeding.

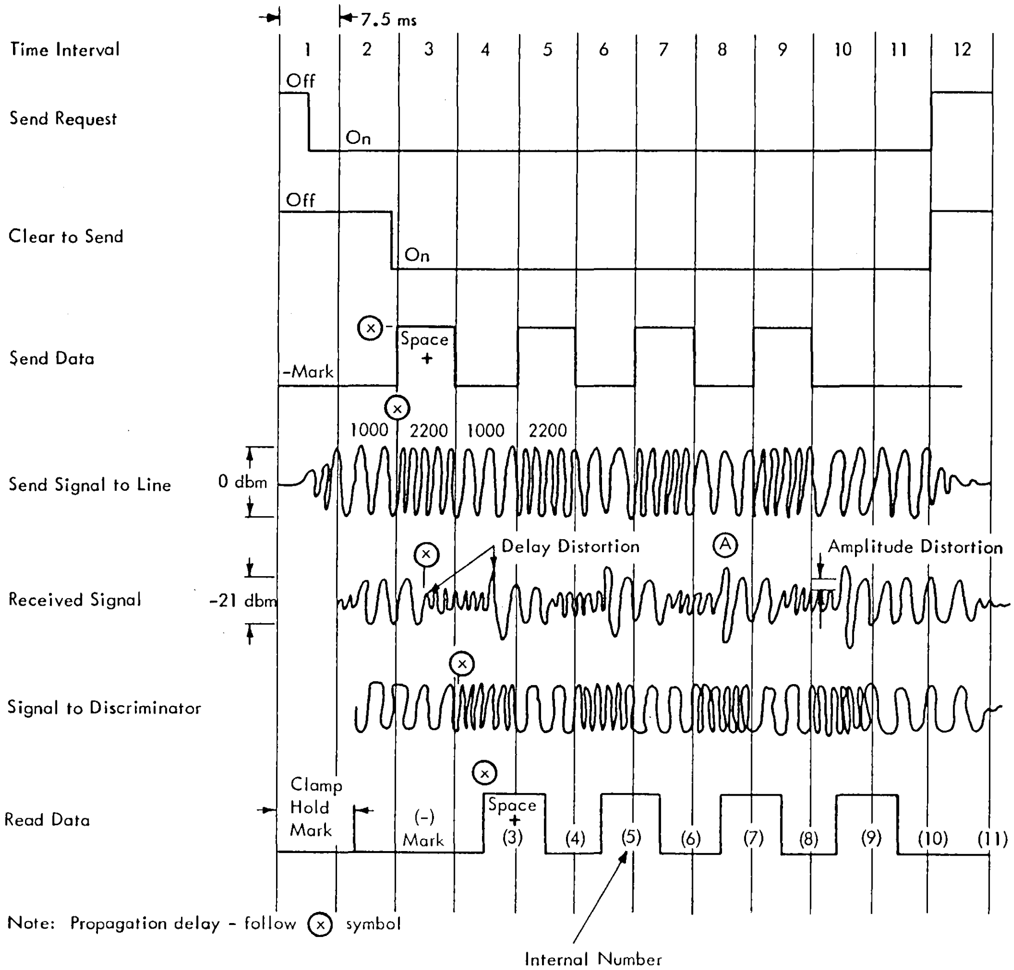


FIGURE 2-26. SIGNAL CORRELATION, IBM LINE ADAPTER

REVIEW QUESTIONS

1. Briefly describe how four data terminals may simultaneously communicate over the same two-wire telephone line by using the IBM Shared Line Adapter.

____
____
____
____
____
____
____
____
____
____
____
____

2. IBM Line Adapters are available for operation at________and________bps.

3. Refer to Table 2-4 and answer the following:
   a. Mark frequency for a Leased Line Adapter type 1B is________cps.
   b. The Space frequency for an IBM Shared Line Adapter operating on subchannel 3 is________cps.

4. IBM Line Adapters and common carrier data sets may be used on the same channel. (True/False)

5. The signal delivered by the high and low frequency modulator is a sine wave. (True/False)

6. When Send Request turns On, the IBM Modem begins to transmit carrier to the communication line. (True/False)

7. The carrier on the line in a "no-data" condition will be the (Mark/Space) frequency.

8. If the signal on the communication line being received by the IBM Line Adapter type 2B is -36 dbm, the Received Data line will be at (Mark/Space).

____
____
____

9. When operating on a customer-owned line with the IBM Line Adapter type 2B,________ milliseconds will elapse between the issue of Send Request and the On condition of Clear to Send.

10. When using the IBM Line Adapter, why is the Received Data line held clamped after Send Request goes Off? ______________________
____
____

11. The Signal Delay circuit forms the signal from the discriminator into uniform rectangular signals on the Received Data line. (True/False)

12. Refer to Figure 2-26 to answer the following: What line characteristic is responsible for the signal peak at (A) ?

____

13. The Send Data line is (+/-) to represent a Space.

14. The Received Data line is (+/-) to represent a Mark.

15. The Received Data line will be (+/-) when no signal is being received.

DATA SET - WESTERN ELECTRIC TYPE 103

This session provides the most frequently required information concerning the operational characteristics of the 103 Data Set.

Highlights:

- FSK modulation
- Mark and Space frequencies
- Answer and Originate mode (data set location initiating call is "originating")
- Automatic answering
- Local mode
- Interface sequences and channel establishment
- Options W, X, Y, Z
- Signal levels
- 103A, B, F compared
- Three interfaces to 103B
  (EIA, CUR, UNI)

The 103 family of data sets is provided for serial binary transmission of digital data up to about 300 bits per second. The upper limit of transmission rate varies with the model. The models we will discuss here are: 103A1, 103A2, 103B, 103F. These data sets present data to the line facility in the form of a frequency-modulated audio frequency carrier. As used here, FM is accomplished by frequency shifting (FSK). For 103 Data Sets, the usual arrangement or assignment of frequencies depends upon which data set is at the location Originating the data call and which data set is at the Answering location. The data set placing the call is considered Originating while the data set responding to a call is considered Answering. These designations arise from terminology which began with the 103A Data Set. The actual frequencies used on the line will depend upon whether Mark Hold or Space Hold option, under idle line condition, is used. This option means that if the data set holds the Received Data line at an EIA Mark level (-3 to -25 volts) when no carrier is being received or when an unmodulated carrier is being received, the data set is considered as being wired for the "Mark Hold" option. If, on the other hand, the Received Data line remains at the EIA Space level (+3 to +25 volts) when either no carrier or unmodulated carrier is being received, the "Space Hold" option exists.

TRANSMISSION FREQUENCIES

Now, for further discussion of the actual transmission frequencies. The sending frequencies used by the Originating data set are F1M and F1S (Mark and Space respectively). The Answering data set sends with F2M and F2S. For the 103A1, 103B, and 103F Data Sets, F1M is 1070 cps while F1S is 1270 cps. These frequencies provide a total shift of 200 cps between Mark and Space. A discriminator circuit in the receiving data set converts the two frequencies to negative and positive voltages respectively on the Received Data line. These same data sets, when operating in Answer mode, use F2M of 2025 cps and F2S of 2225 cps which again produces a shift of 200 cps.

The 103A2 uses reversed Mark and Space frequencies as follows: F1M = 1270 cps, F1S = 1070 cps, F2M = 2225 cps, and F2S = 2025 cps. For a graphic representation of the relationship of the frequencies as they are used for the 103A1, 103B, and 103F, see Figure 2-27.

A representative block diagram of the 103 Data Sets is given in Figure 2-28. This diagram is for the 103A, but the other members of the 103 family are similar.

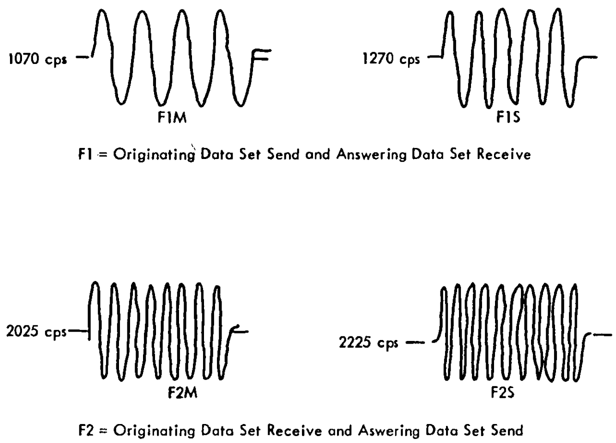


FIGURE 2-27. DATA SET WE 103, FREQUENCIES

INTERFACE

There are some differences between the interfaces used by the various 103 Data Sets. For the 103A, see Table 2-5; for the 103B (with EIA interface) see Table 2-6; and for the 103F see Table 2-7. The various lines have been previously defined and discussed in Session 8.

OPERATIONAL KEYS

Some 103 Data Sets may have all of the following keys while others may only have one. The number depends on the model.

1. AUTO — Selected Auto answer mode for incoming calls.
2. LOCAL — Connects the Send and Receive lines together inside the data set.
3. TEST 2 — Used at direction of data test center.
4. TEST 1 — Used at direction of data test center.
5. TALK — Connects the telephone to the line instead of connecting the data set to the line.
6. DATA — Disconnects telephone set from the line and connects the data set to the line.

If TEST 1 or 2 is erroneously activated, depressing the DATA key will release the data set from the test mode. On some data sets, activating the TEST keys after channel establishment has been completed can sometimes cause a shift from Originate to Answer mode of operation or vice versa. Some data sets which have been permanently wired for either Answer or Originate mode of operation will have only one TEST key.

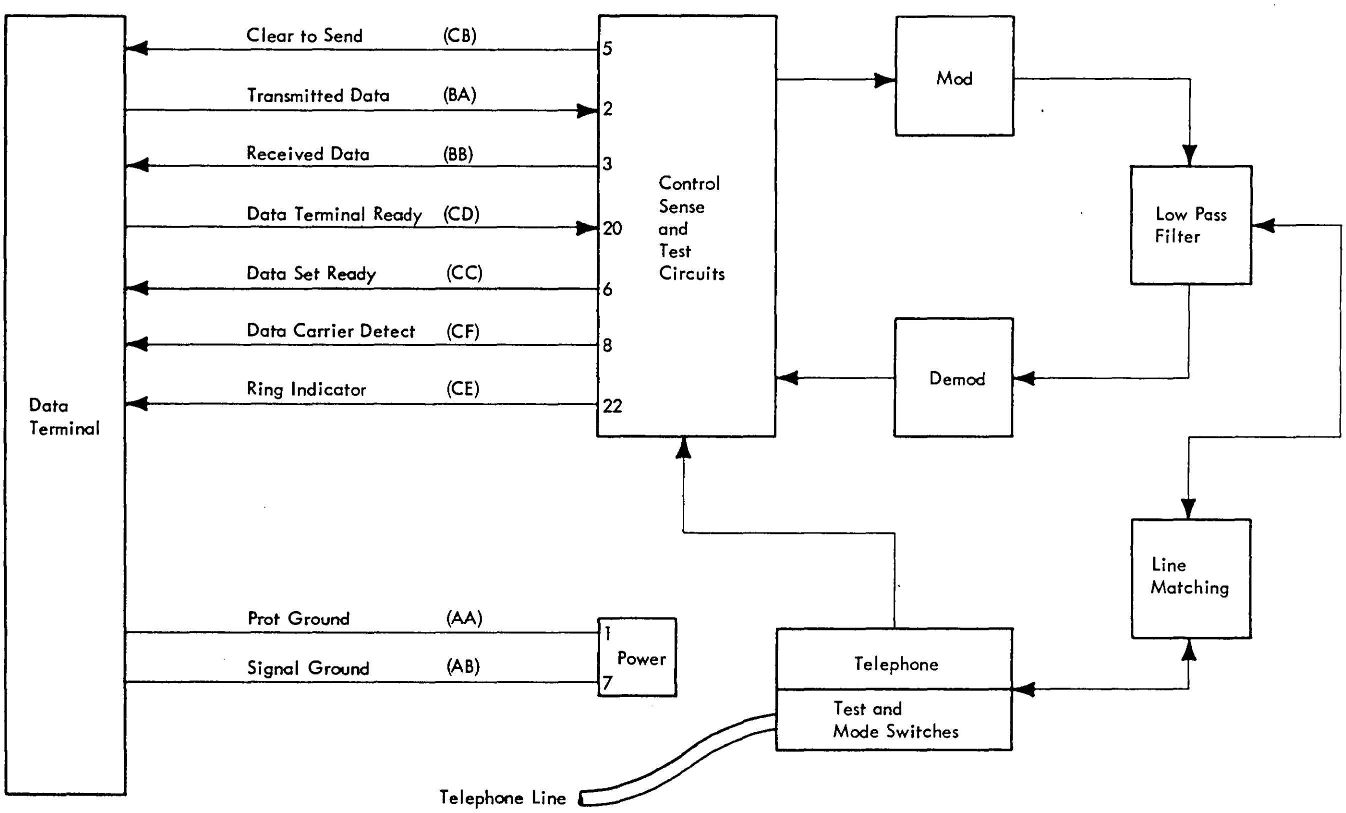


FIGURE 2-28. WE 103A DATA SET, BLOCK DIAGRAM

TABLE 2-5. INTERFACE LINES 103A

Pin	Circuit	Name	Function
1	AA	Protective Ground	Common to signal and power ground.
2	BA	Transmitted Data	Serial binary data to 103.
3	BB	Received Data	Serial binary data to the terminal.
4			
5	CB	Clear to Send	Signal terminal to send data.
6	CC	Data Set Ready	Data set in Data mode means Request to Send is On and carrier is being generated to the telephone line.
7	AB	Signal Ground	See Pin 1.
8	CF	Data Carrier Detector	Data Carrier being received from remote data set.
9	+P	Plus Power	Reserved (Telephone Company Use)
10	-P	Negative Power	Reserved (Telephone Company Use)
20	CD	Data Terminal Ready	On to allow Auto Answer in response to Ring Indicator On. (Data set now begins to generate carrier.)
22	CE	Ring Indicator	On Signal to data terminal when a "ring" signal is on the line.

APPLICATIONS

The 103A Data Sets are normally used on dial-up facilities and may be provided with either an integrated telephone instrument or a separate but electrically connected telephone. In the latter case, either an 804 Data Set auxiliary or a 567PB type telephone may be encountered. The 804 is a small box with a cradle for the handset and six keys for controlling the operation. The 567PB looks like a normal business telephone for use in extension service and and has six keys along the bottom for controlling operation.

The 103B and 103F Data Sets are intended for use on leased private lines and therefore do not have the alternate-use telephone instrument. The 103B Data Set requires some leads to be controlled at the interface through contact closure rather than through EIA voltage levels. The 103F has an interface which conforms to EIA RS-232-A. These leads are noted in Tables 2-6 and 2-7.

The 103B has three possible interfaces which may be used:

- EIA for bi-polar signals (+3 to 25 volts and -3 to 25 volts)
- UNI for uni-polar signals (0 to -12 volts)
- CUR for current mode operation with 60-ma loop current, except in Local, at which time RD current is 70 ma.

CHANNEL ESTABLISHMENT

The establishment of a channel varies among the various models of the 103 Data Set. Each sequence of operation will be explained.

TABLE 2-6. INTERFACE LINES - 103B

Pin	Circuit	Name	Function
1	FG	Frame Ground	Common signal and power ground (usually but not necessarily).
2	SD	Send Data	Serial binary data to data set.
3	RD1	Received Data	Serial binary data to terminal.
4			
5	IT	Interlock	Power is On and data set is in Data mode.
7	SG	Signal Ground	See Pin 1.
8	LO	Local	Contact closure to SG provides Local mode in which SD is looped back on RD1 for local testing of interface.
9	+P	Plus Power	Reserved (Telephone Company use)
10	-P	Negative Power	Reserved (Telephone Company use)
11	AN	Answer Mode	Contact closure to Signal Ground to set Answer mode of operation.
14	RS	Request to Send	Data set begins generating carrier when this line is turned On.
15	CN	Connect	This line turns On when carrier has been received from the remote data set.

NOTE: The terms "Send Data" and "Transmitted Data" are used interchangeably in discussing data sets.

TABLE 2-7. INTERFACE LINES 103F

Pin	Circuits	Name	Function
1	AA	Protective Ground	Common with signal and power ground.
2	BA	Transmitted Data	Serial binary data to data set.
3	BB	Received Data	Serial binary data to terminal.
4	CA	Request to Send	Data set begins generating carrier when this line turns On.
5	CB	Clear to Send	Data terminal may begin sending data on circuit BA when circuit CB turns On.
6	CC	Data Set Ready	Data set operational; compares with Interlock of the 103B.
7	AB	Signal Ground	See Pin 1.
8	CF	Data Carrier Detect	This line turns On when carrier is received from the remote data set and compares with the Connect line of the 103B.
9	+P	Plus Power	Reserved (Telephone Company use)
10	-P	Negative Power	Reserved (Telephone Company use)
11	CY	Originate Mode	When this lead is On (+), it sets the data set in the Originate mode. Same operation as 103B Answer lead but is voltage-controlled.
12	CX	Local Mode	An On condition (+) of this lead places the data set in Local mode and loops circuit BA back on BB for testing purposes.

Manual Channel Establishment (103A1)

Here is the sequence of events leading to channel establishment when manual answering of calls is used.

1. Originating terminal operator places call. (103A1 in Talk mode).
2. Answering terminal operator lifts receiver and answers (103A1 in Talk mode). Receiving a ring selects Answer mode for data set.
3. Answering operator depresses DATA key and releases it. This releases the TALK key and the light under the DATA key turns On. 1-1/2 second timeout begins to assure that central office on Originating end detects an "off-hook" condition at the Answering end to terminate ringing.
4. When timeout is over, the Answering data set begins transmitting a 2025-cps carrier (F2 Mark).
   This 2025 tone disables any echo suppressors on the line and, as long as tone signals continue to be exchanged, the echo suppressors should remain disabled.
5. Originating terminal operator hears 2025 signal and depresses DATA key and it becomes illuminated. Release DATA key.
6. Begin 1-1/2 second timeout.
7. At end of timeout, begin transmitting 1070-cps F1 Mark.
8. Clear to Send (CB) turns On (+) to signal channel establishment complete.
9. Data terminal begins delivering serial data bits on Transmitted Data (BS) lead.

Termination at completion of data call is as follows:

1. When message is transmitted, data terminal may turn Off CE (Data Terminal Ready). This forces an "on-hook" signal to break the connection.

   OR

2. Both ends may depress TALK keys and hang up the handset.

Automatic Channel Establishment

Automatic channel establishment is under control of either of two data set options:

1. Option W - When AUTO key is activated, the data set will automatically answer incoming calls.
2. Option Z - AUTO key of no use - all incoming calls answered automatically.

Either case also requires that CE circuit is On. Other than this difference, the channel establishment is as under "Manual Channel Establishment". The 103A2 performs similarly but with inverted Mark and Space frequencies.

Other options available are:

1. Option Y - if operation without ACU is required.
2. Option X - if operation with ACU is required.

When Auto Answer is employed, Disconnect and Initiate Disconnect options are normally wired in at the factory unless specifically requested to be omitted.

Auto Disconnect functions as follows:

1. Initiate Disconnect - signal momentary Off on CD lead (Data Terminal Ready) and data set transmits a 3-second Spacing frequency signal. Station goes "on-hook".

2. Respond to Disconnect - when receiving data set identified 1-1/2 seconds of Spacing frequency on line, it disconnects and goes "on-hook".

Channel Establishment for 103B Data Set

For purposes of this explanation, the sending terminal will be designated Originating and the receiving terminal will be designated Answering. On is positive, Off is negative.

When the Originating terminal wishes to send, it must turn On the Request to Send lead (RS). The data set begins sending a carrier on the telephone line at the Originate Mark frequency (1070 cps). Any time greater than 200 milliseconds after RS is turned On, the terminal may begin gating data to the Send Data lead (SD).

At the Answering data set, receipt of carrier for 30 milliseconds turns On the Connected lead (CN) and should cause the Answering data set to turn On Request to Send, if its Interlock lead (IT) is On.

When the Originating data set receives carrier from the Answering data set (2025 cps) for a period of 30 milliseconds, the Originating data set delivers an On condition to the sending terminal on the Connected lead. The sending terminal may now begin gating data bits to the SD lead. Connect (CN) On really constitutes a Clear to Send signal. When the sending terminal completes operation, it terminates the call by turning Off RS. During the first 30 milliseconds after RS is dropped, transient responses may occur on the RD lead of the Originating data set. The data terminal must assure that these responses are not interpreted as data.

Channel Establishment for 103F (see Figure 2-29)

When the Originating data terminal wishes to transmit, it turns On the Request to Send line (A) of the Originating data set. This causes the Originating data set to begin sending carrier on the line. In 200 milliseconds from Request to Send On, the Data Carrier Detect line (B) in the Answering data set goes On. As of this time, the answering data set could receive data but it is recommended that data not be sent until Clear to Send (C) goes On at the Originating data set 265 milliseconds after Request to Send was turned On.

When terminating the sequence, the Originating terminal turns off Request to Send (D), and the Originating data set runs off Clear to Send and ceases transmitting carrier. The Data Carrier Detect line at the Answering data set (F) goes Off 50 milliseconds after loss of carrier.

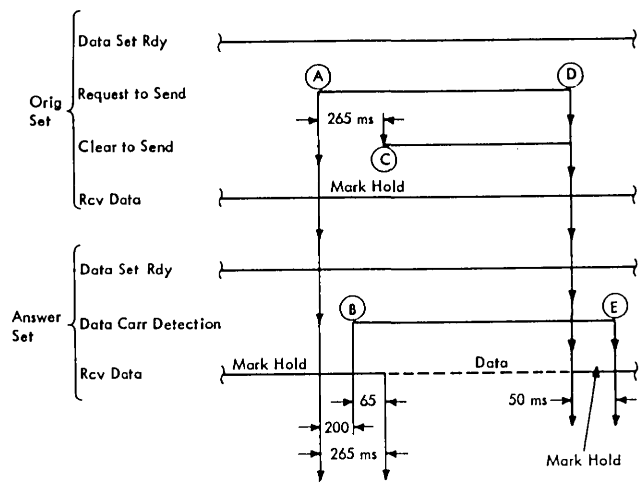


FIGURE 2-29. DATA SET WE 103F, INTERFACE SEQUENCE

The text for this session is concluded. You should be able to answer all the review questions by using the text as a reference. When you have completed answering the questions, proceed to the next session.

REVIEW QUESTIONS

1. The Mark frequency for a 103 Data Set in Answer mode is________cps while its Space frequency is________cps. If the data set is in Originate mode, these frequencies become ________and________cps respectively.

2. In Local mode, the data set does not place a signal on the line but does repeat the Send Data signal on the Received Data line. (True/False)

3. A 103A in Automatic Answer mode responds to a ring signal by sending a signal at 2025 cps. (True/False)

4. The 103A is intended for operation up to ________bits per second on dial-up lines.

5. Data Terminal Ready (CD) is the response from the data terminal to a Ring signal on circuit CE provided:____________________
____
____

6. The initial 2025-cps tone sent by the Answering 103 will disable any________ ________on the line.

7. The following questions deal with Options:

   a. Automatic Answer in response to a ring signal with AUTO key depressed is provided by Option________.
   b. If all incoming calls are to be answered regardless of AUTO key, Option________ is installed.
   c. If operation with an Automatic Calling Unit is required, Option________is installed while Option________provides for operation without ACU.

8. Data Sets 103A and B use Interface EIA ________while the 103E and F use EIA ________.

9. The________interface lead provides a means for the data terminal to switch the data set between Originate and Answer modes.

10. A binary 1 is considered as a (Mark/Space) which is (+/-) or from a control standpoint (On/Off).

11. When using the 103F, Clear to Send turns On ________milliseconds after Request to Send turns On.

12. The receiver of a half duplex 103F will stay Off for approximately________milliseconds after the fall of Request to Send.

13. If a 103 has been factory-wired with Auto Answer, then a receipt of a 1-1/2 second Spacing signal tells it to go ("on-hook"/"off-hook").

14. A 103F Data Set is found to deliver a Received Data signal of +4 volts for a Space. Is this an acceptable signal? Why?________________
____
____

15. The 103B may be equipped with any of three interfaces, which are:________,________, or________.

16. When an operator at an Answering 103A Data Set depresses the DATA key, a carrier at 1070 cps will be transmitted. (True/False) Explain. ________________________________
____
____
____
____
____

17. The Initiate Disconnect signal is____________
________________________________.

18. If the data terminal delivers a $\pm$ 4-volt signal on the Send Data lead to a 103F, it is acceptable. (True/False)

DATA SET - WESTERN ELECTRIC TYPE 202

This session provides the most frequently required information regarding the operational characteristics of 202A, B, C, and D Data Sets.

Highlights:

- FSK modulator
- AGC - Auto or semiautomatic
- Interface line assignments
- RS-232 compared to RS-232-A
- Attended and Unattended Answering
- Channel requirements
- Error expectancy
- Distortion limits

GENERAL

The 202 Data Sets are similar in principle to the 103. The 202 Data Sets use a shift of frequency from about 1200 cps to 2200 cps to represent a change from a Mark to a Space. These data sets do not use a second simultaneous channel, through frequency division multiplexing, for FDX (full duplex) operation on a two-wire telephone line. The 202 Data Sets require a four-wire telephone lines to accomplish FDX operation.

The models of the 202 in which we are interested are the A, B, C, and E. The A and B are considered obsolete but many are still in use and most of our machines operating in the data rate range of the 202 are interfaced for the A and B type rather than the C and D. The 202A and B interface more closely resembles the EIA RS-232 interface rather than the RS-232-A in that "contact closure" is utilized instead of voltage on certain interface leads.

The 202A is intended for dial-up service; the 202B is intended for leased private line service, either two-wire or four-wire. Neither the A nor B has the capability of operating with the standard 801 type of Automatic Calling Unit (ACU). ACU enables a computer to dial the telephone number you are calling. A special "model shop" version of the ACU is available for use with the 202A and B.

The 202C is a more recent model for dial-up service, and the 202D is a recent model for two-wire or four-wire leased private line service. Remember that the two-wire model is for half-duplex (HDX) operation and the four-wire model is for FDX operation. Various combinations of the 202D and 804 Data Set auxiliaries can be provided to afford alternate use telephone communication on either two-wire or four-wire telephone leaded private lines.

From the standpoint of data handling, the 202 Data Sets provide the capability of sending and receiving up to 1800 bps of serial binary data. The exact upper limit is a function of the of the quality of line employed. A representative block diagram of the 202 Data Set is provided in Figure 2-30.

DIFFERENCES - A AND B VS. C AND D

The 202A and B Data Sets have a manual control to adjust the dynamic Automatic Gain Control (AGC) circuit in three ranges as follows:

1. 10 dbm to -20 dbm
2. -5 dbm to -35 dbm
3. -20 dbm to -50 dbm

These figures represent ranges of input signal level from the line to the data set. THEY ARE SET ONLY BY TELEPHONE COMPANY PERSONNEL.

The 202C and D have a fixed AGC circuit which does not require manual intervention. In a "multipoint" network, certain terminals could fail to perform properly, while these same terminals may work satisfactorily with every other terminal in the network. This problem can be traced, in some cases, to a poor selection of AGC range switch setting on the 202A or B. Imporper setting of the AGC range can usually be detected at the interface as a

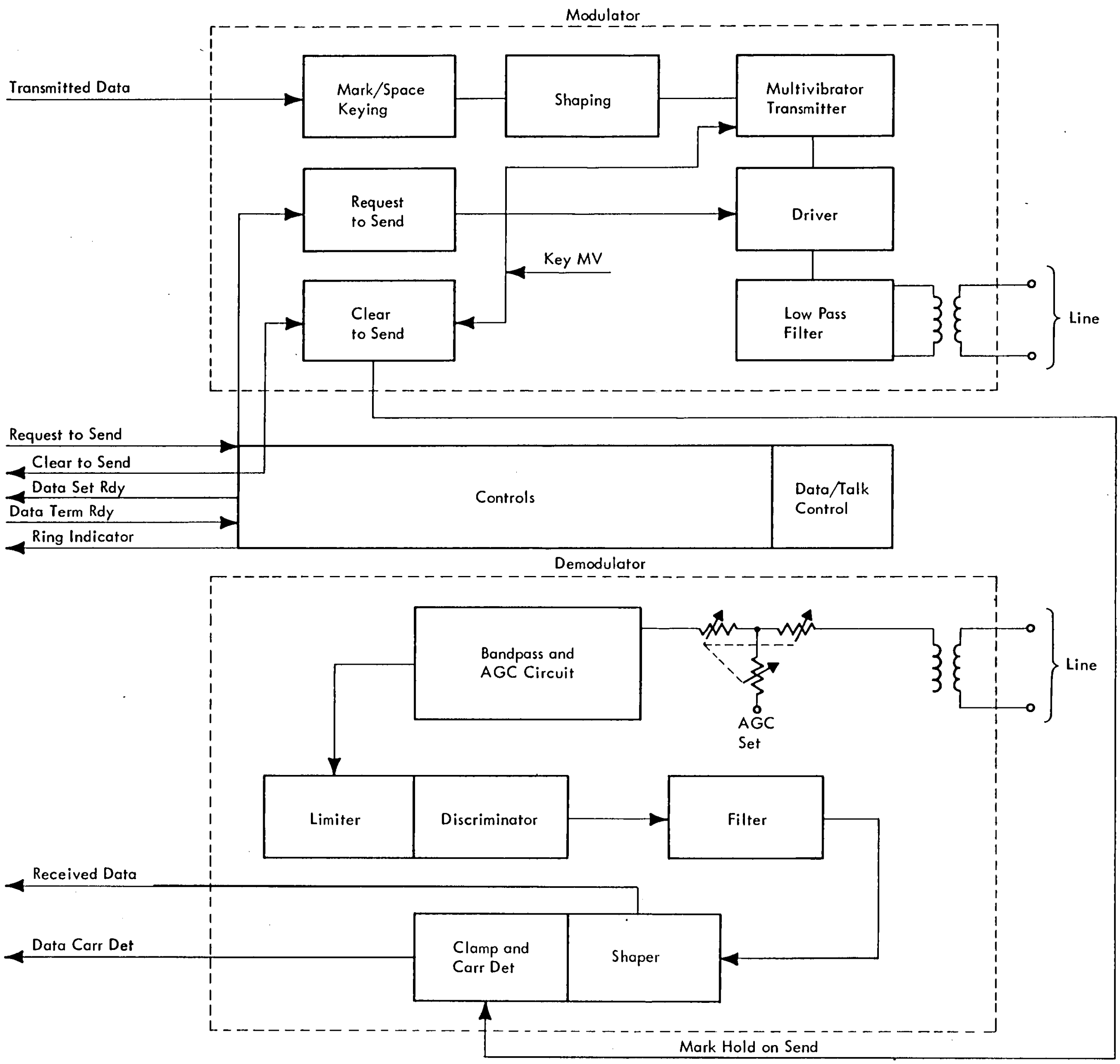


FIGURE 2-30. DATA SET WE 202, BLOCK DIAGRAM

Mark/Space ratio that shows excessive jitter and, if the condition is bad enough, may cause intermittent loss of Data Carrier Detected (CF) lead.

The 202A and B Data Sets require that the Request to Send line have a rise time of less than 25 milliseconds or the carrier generator may fail to operate. This problem does not exist with the 202C and D. When Request to Send is turned Off to the 202A or B, the carrier generator gradually dies out, causing echo problems; the 202C and D, provided the Transmitted Data lead is held Marking when Request to Send is turned Off, will shift the carrier out of the data frequency band, but not Off. This method of control eliminates the echo problem to a great extent and improves "turn-around" time.

The 202C and D data sets have improved Phase Delay Compensation. This was discussed in Session 9 (Figure 2-26) showing the effects of phase delay. Equalization or compensation of the phase delay helps overcome the distortion created by the unequal velocities of the 1200-cps signal and the 2200-cps signal on the telephone line.

Another feature of the 202C and D is the ability to disable echo suppressors on the line when they

answer a call. This disablement of the echo suppressors is accomplished by transmitting a burst of carrier at 2025 cps before shifting to the Marking frequency of 1200 cps. This feature is necessary to operate with the standard 801 ACU and also to provide for the use of an optional, very low-speed reverse sending channel on two-wire lines for some error recovery techniques. The reverse is not presently required by IBM data terminals.

INTERFACE

The interface lead assignments for these data sets are shown in Table 2-8. Leads 19 through 23 vary in signal characteristics depending upon whether RS-232 or RS-232-A interface is used.

NOTE: As an option at time of ordering, the 202C and D may be equipped with the 232 instead of the 232-A interface until notice of suspension by telephone company. The customer should request "202A type Interface."

When the RS-232 interface is used, RY, RR, RC and RI are contact closure leads. A terminal providing closure between RY and RC or between RC and RR indicates an On condition to the data set. RR to RC closure is necessary to place the data set in Data mode. If the terminal is not arranged to use the Remote Release feature, RR and RC should be permanently strapped together at the terminal. In IBM equipment, this strapping is usually done by jumpering pins 19 and 20 on the DB-19604-432 connector on the data set end of the interconnecting cable.

TABLE 2-8. INTERFACE LEADS 202A, B, C, AND D

Pin	Circuit	Name	
#	Symbol	RS-232-A (202C and D)	RS-232 (202A and B)
1	AA	Protective Ground	Frame Ground (SG)
2	BA	Transmitted Data	Send Data (SD)
3	BB	Received Data	Received Data (RD)
4	CA	Request to Send	Request to Send (RS)
5	CB	Clear to Send	Clear to Send (CS)
6	CC	Data Set Ready	Interlock (INT)
7	AB	Signal Ground	Signal Ground
8	CF	Data Carrier Detector	Carrier On-Off
9		Power - Telco Test	Positive Power
10		Power - Telco Test	Negative Power
11	SA	Supervisory Transmitted Data	
12	SB	Supervisory Received Data	
13-18		Unused	
19		Unused	Remote Release (RR)
20	CD	Data Terminal Ready	Remote Control (RC)
21		Unused	Ready (RY)
22		Ring Indicator (CE)	Ring Indicator 1 (RI)
23			Ring Indicator 2 (RI)
23			
24		Unused	
25		Unused	

CHANNEL ESTABLISHMENT

A description of the operation for the 202A and B in HDX operation follows:

1. Operator places call and switches data set to Data mode.
2. Data set delivers Interlock On to the data terminal; as above, RR to RC must be closed or data set cannot get into Data mode. Interlock means: Data set power is On, data set is in Data mode, and data set is connected to the line.
3. Data Terminal issues Request to Send. This turns on the carrier generator in the data set.
4. When 200 $\pm$ 20 milliseconds had timed out since issue of Request to Send, data set returns Clear to Send On to the data terminal. This 200 milliseconds is necessary to allow any echo suppressors in the line to "turn-around". This period also allows the remote data set to respond to the carrier and remove the "hold" from the Received Data line.
5. Data terminal may now begin placing serial-binary data bits on the Send Data line.
6. The local (sending) data set unclamps the hold on the Received Data line 50 $\pm$ 10 milliseconds after the rise of Request to Send. The remote (receiving) data set does the same thing in response to Carrier.
7. At the local data set, the local carrier detect circuit turns On. Thus, SD will be repeated on the RD lead for monitoring purposes.

Unattended answering may be provided if the data terminal responds to a closure of the Ring Indicator lead by closing RY to RC as well as keeping a closure on RR to RC. RY to RC can be released once it has been made and the call terminated by opening RR to RC.

ERROR EXPECTANCY

Quoting from the Interface Specification for 202C and D, "A long term average of 1 bit error per 100,000 bits transmitted or better on working circuits would be expected, but not guaranteed, if data sets are associated with the type of Schedule 4 private line

channels recommended in Part 5.3". The recommended Schedule 4 line types follow:

	Recommended Max. bit rate 202A and B	Recommended Max. bit rate 202C and D
Type 4	750	1000
Type 4 A	1400	1400
Type 4 B	1800	1800

The specifications for Peak Distortion state an objective of 20 percent or less. This is the sum of Jitter and characteristic distortion.

REFERENCE SOURCE

For additional details regarding primary and optional interface sequences in attended or unattended (auto answer) modes, and for information of configurations possible including the use of Automatic Calling Units with the 202 data sets, refer to the Interface Specification books cited in the bibliography. If you have a specific question, contact your Area Communications Specialist.

The text for this session is concluded. Answer the following review questions using the material presented in this session. When you have answered the review questions, proceed to the next session.

REVIEW QUESTIONS

1. What is the maximum data rate for which the 202 data set is intended? ________

2. How do the 202A and B differ from the 202C and D in regard to the interface? ________

3. What may happen if the rise time of Request to Send exceeds 25 ms? ________

4. Explain the difference in operation of Interface leads 19 and 20 with RS-232 and RS-232-A. ________

5. Clear to Send turns On ________ milliseconds after Request to Send is issued.

6. Interface lead to pin number 6 is On if auxiliary telephone set is in Talk mode. (True/False)

7. A 202C or D Data Set can be provided to work with IBM terminals interfaced to RS-232. (True/False)

8. When a half duplex 202 is sending, how can you check to be sure that the signal is getting from the Send Data line into the data set, if no signal is being received at the remote terminal? ________

9. What is the maximum amount of Mark or Space distortion you should find on the Received Data line? ________

10. What leased line facility of the telephone company is required if a 202C data set is to be operated at 1200 bps. ________

DATA SETS FOR PARALLEL DATA AND AUTOMATIC CALLING

This session will familiarize you with the 400 and 800 series of data sets. The 400 series is for parallel data transmission, and the 800 series makes it possible for a data terminal to place a telephone call to another terminal.

Highlights:

- 401A and B handle numeric information in 2 out of 8 code.
- 401E and F handle alphameric data in 3 out of 14 code.
- Interface control
- Unattended operation
- 402 Data Set can handle up to 8 level codes.
- 403 Data Set can receive tone dialing digits as inquiry to Voice Answerback equipment.
- 801 Automatic Calling Unit lets terminal dial number on telephone line.
- 801 Interface and sequence
- End of Number operation
- Options Y and Z

DATA SETS - WESTERN ELECTRIC 400 SERIES (PARALLEL DATA)

The data sets included under this heading are: 401A, B, E, F, H, J, 402A, B, C, D, and X403A. The data sets described below are relatively low-speed devices capable of parallel bit signalling through the use of multi-tone signals on the line.

Western Electric 401 Series

This series consists of the 401A, B, E, F, H, and J. The 401E and F replace the 401A and B respectively.

The 401E is a parallel transmitter capable of transmitting 99 different characters for data plus one separator character in a 3 out of 14 code. The maximum transmission rate is 20 characters per second. This is the type of data set which would be used with the IBM 1001 Data Transmission System. The data set is controlled by contact closures in the data terminal equipment to present 3 out of 14 different frequencies to the telephone line for each character to be transmitted. The frequencies are designated:

A0, A1, A2, A3, A4
B0, B1, B2, B3, B4
C0, C1, C2, C3

} one control closure, and only one, in each group.

The 0 frequencies represent the frequency generated without any contact closure in that group. Character separator is A0, B0, C0.

The 401F data set is the receiving element of this system and is capable of delivering data to a data terminal in the form of 3 out of 14 contact closures as a result of demodulating the transmitted signal from the 401E. See Figure 2-31 for the system hook-up including the required interface lines. The 401E and F can process alphabetic and numeric information. The earlier 401A and B could only process numeric information and employed eight frequencies with a 2 out of 8 closures code.

Operation in Data Mode requires leaving the telephone handset off the cradle and lifting the left hand "switch-hook" contact button. Hanging up the handset restores Talk mode and places the line "on-hook".

Sequence of Send Operation

1. Data contacts close in data terminal.
2. Key contact closes.
3. Data contacts open.
4. Key contact opens.

No external arc suppressors may be used with the data contacts or the transmitter will be detuned.

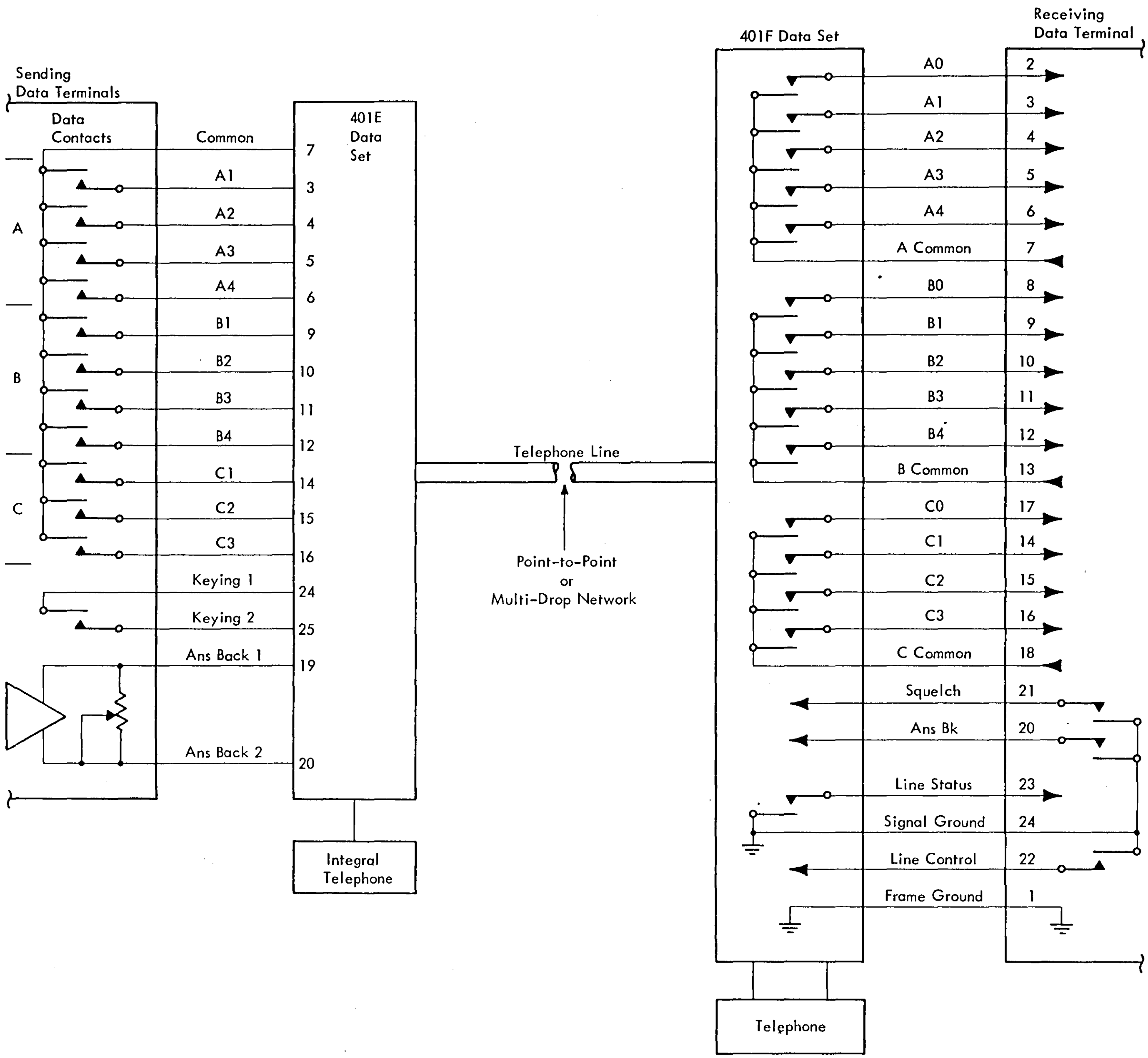


FIGURE 2-31. DATA SETS WE 401E AND F, HOOKUP

Receive Operation

Contact closures are delivered on the interface lines to the data terminal which correspond to those activated at the sending terminal.

NOTE: A single (instead of 3) closure at the transmitter results in one closure at the receiver. No closures at the transmitter produces only separator at receiver. If two contacts are closed in a transmitting group, no closure occurs at the receiver for that group. This means that if a noise pulse interferes, it could add a closure causing a receipt of none, or it could subtract a closure causing a receipt of none.

At the receiver, the squelch line must be grounded to receive and open to send an Answer Back signal. If the telephone line opens, the squelch line opens.

Unattended Operation

When Line Control lead is closed, calls will be answered; when opened, the 401 goes "on-hook". Line Status will be closed by the data set when it is ready

to receive (Data mode selected). The line will be disconnected if Line Control (LC) is opened for 0.1 second. The closure of Line Status signals "off-hook" to the central office by sending a 3-second Answer Back tone on the line.

If operated on leased lines, a Schedule 4 type 4A line is required.

The 401H provides transmission facilities only. It can transmit only numeric information based on 2 out of 8 closures or alphameric information in 3 out of 14 closure code. The line transmission signals are multiple tones. This data set provides a means for the user to change at the interface from parallel transmission to serial bit FSK. The proposed applications for the 401H include telemetry, remote metering, and data logging.

The 401J data set compares with the 401F and is capable of receiving 3 out of 14 code signals.

Western Electric 402 and 403 Series

The 402A and B Data Sets comprise a transmitter and a receiver. The 402 is similar to the 401 except that up to eight levels of coding may be processed at speeds up to 75 characters per second.

The 403A Data Set is capable of delivering numeric information to a data terminal in the form of 2 out of 8 contact closures in response to digits received from a TOUCH-TONE* telephone or a 403 transmitter. The 403A can also be arranged to operate with Automatic Calling Units (ACU). The data set provides a means of presenting a digital inquiry to an Audio Response Unit such as the IBM 7770 and receiving a voice answer back. The X403A will operate "unattended"; that is, in an Auto Answer mode. To see the coding involved for developing digits, refer to Figure 2-5, Tone Dialing Digits.

DATA SETS - WESTERN ELECTRIC 801 AUTOMATIC CALLING UNIT (ACU)

Two types of ACU's are discussed: the 801A and 801C. The 801A is for use in rotary dial type telephone systems while the 801C is for operation with tone dialing systems.

The 801 ACU enables telephone calls for data communication to be placed under full computer control. The computer issues a call request to the ACU and, if the line is not already busy, transfers the necessary dialing digits to the ACU to complete the calling sequence. When the dialing is completed, two options exist: The computer may issue one more signal, called End of Number (EON), to the ACU, whereupon, the ACU immediately transfers the communication line to the actual data set to be used, and the computer monitors the Data Carrier Detector line of the data set to determine when the channel has been established. The other option is for the ACU to stay on-line after the last actual digit of the number being called has been delivered and wait to receive a 2025-cps answer signal from the remote data set as a signal to transfer the communication line to the actual data set at the computer location.

The 801A delivers dc dialing pulses to the line; the 801C delivers tones (see Figure 2-5) to the line. A Test mode of operation is also provided for the 801. When operating in the Test mode, the circuit can be dialed and the Call completed, but no data can be transmitted because the ACU automatically terminates the call after approximately 40 seconds in Test mode.

Interface

The interface lines for the 801 are shown in Figure 2-32.

Operational Sequence

1. The computer issues a Call Request (CRQ). The ACU takes the line away from the "using" data set unless it is already busy as indicated by an On condition of Data Line Occupied (DLO).
2. When the central office recognizes that the ACU is "off-hook", DLO turns On and in turn the Present Next Digit (PND) line turns On.
3. In response to PND, the computer places the digit to be dialed on the NB1, 2, 4, and 8 leads of the interface in BCD format and signals the presence of the digit to the ACU with Digit Present (DPR).
4. The ACU acknowledges the digit by dropping the PND line and delivers the digit to the line in the proper form (pulse or tone). PND will not come On again for at least 600 ms.
5. PND turns On again and DPR goes Off. Computer supplies next digit and turns On DPR again.
6. This sequence continues until the computer stops supplying digits in response to PND. (Note that the computer may also deliver the EON signal, a One on the NB4 and NB8 leads if End of Number mode of operation is used.)

Options

If the data call is not completed for any reason, the Abandon Call and Retry line will turn On. The amount

* Trade Mark of AT&T and Bell System

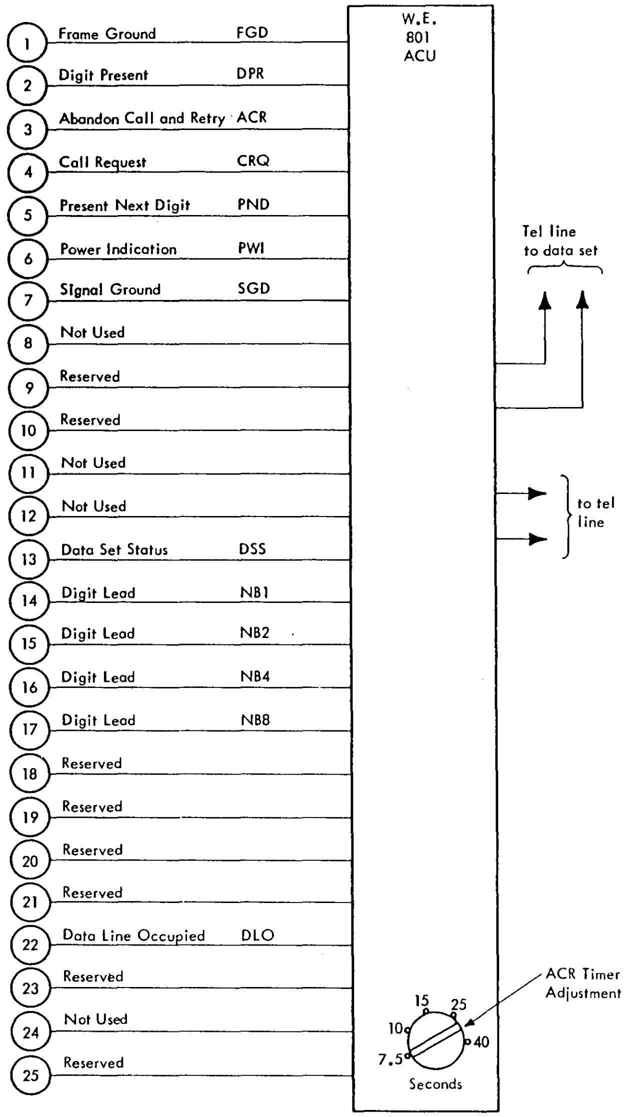


FIGURE 2-32. AUTOMATIC CALLING UNIT, WE 801A INTERFACE

of time allocated for a call to be completed and the channel established, as evidenced by Data Set Status (DSS) turning On, may be set to 7, 10, 15, 25, or 40 seconds under control of a switch. The ACR adjustment switch is located under the front nameplate of the 801. The customer may set this switch for the time desired. Normally, CRQ is held up during the entire data call, and the ACR timer is locked out as soon as the CRQ is turned off. An option is provided to overcome this problem so that if the Data Carrier Detector line does not turn On in a reasonable time, the ACR line will turn On to signal the computer that the call was not completed and will not leave the equipment hung up. When EON is not used, the data call is terminated by turning Off the CRQ line. If EON operation is used, the Data Terminal Ready line or some similar means must be used to terminate the call via the data set rather than through the ACU. It should be noted that the On condition of ACR does not, in itself, terminate the call, but only advises the computer to do so. The computer then terminates the call as described above.

In the area of options, consideration must also be given to the data set at the called location since some of the data sets do not generate the required answer signal, while others generate the answer signal under special controls for a short duration. The 801 must be able, under various options, to operate under the following conditions:

1. Receive 2225 cps as an Answer signal from 103A2.
2. Receive 2025 cps as an Answer signal.
3. Computer equipment terminate call by dropping CRQ.
4. Computer equipment terminate call via data set.
5. ACU transfer line to "using" data set at beginning of answer tone.
6. ACU transfer line to "using" data set at completion of dialing (EON operation).
7. Retain ACR timer operation after CRQ is Off until DSS turns On.
8. Line transfer at beginning or end of answer tone.

The only one of these options we have not examined is the last. The 103 Data Sets normally use 2025 or 2225 cps as a transmitting frequency for the answering data set; therefore, when the ACU operates to terminals using 103 Data Sets, it will transfer the line at the beginning of the answer tone. When the ACU is calling a terminal using a 201 or 202 Data Set, neither 2025 nor 2225 cps is normally available in the transmission frequencies; special circuitry in the 201 or 202 Data Set is required to generate a short burst of 2025-cps answer tone before switching to the normal Mark frequency. To work with these data sets, the ACU must have the transfer line at "end of answer tone".

NOTE: The 801C ACU has an interface complying with EIA RS-232-A. The 801A3 has a "contact closure" interface, and the 801A4 has the RS-232-A interface .

REVIEW QUESTIONS

1. The 400 series data sets are used mainly for (serial/parallel) data transmission.

2. The maximum data rate of the 401E Data Set is________characters per second in________ code.

3. If a 401E sends a signal consisting of closures on A1, A2, B1, and C3, what will be received and transferred to the receiving terminal by the 401F Data Set?
   a. A1, B1, C3
   b. A2, B1, C3
   c. A1, A2, B2, C3
   d. B1, C3

4. The frequency combination A0, B0, C0 is used as a________ ________.

5. Where is the DATA key for a 401 data set located?________________________________
____
____

6. When a 401F is receiving, the Squelch line must be: (grounded/open).

7. In Unattended operation, how does the 401 terminate a call?
   a. open LC for 100 milliseconds
   b. open LS for 100 milliseconds
   c. close LC for 100 milliseconds
   d. close LS for 3 seconds

8. How does the 401H differ from the 401E from the standpoint of data handling?____________
____
____
____
____
____

9. How many levels of coding may be used with the 402A and B Data Sets and at what maximum data rate?________________________
____

10. Which data set can be used to provide signals to a data terminal in response to the keying of the buttons on a tone-dialed telephone?

11. When an 801 Data Set is used to place a call, each digit is requested by the________line from the interface pin________.

12. When the data terminal has a digit available for the ACU, it signals this fact by raising the________interface line at pin number ________.

13. The data terminal signals its intent to make a call with the________line to pin #________.

14. When the________line comes On, the telephone line will be transferred to the data set.

15. If a call is not completed, the 801 will signal ________to the data terminal from pin number________.

16. If the data terminal drops the CRQ line after calling the remote terminal, what will the 801 do?________________________________
____
____
____

17. If DLO is already On when CRQ is issued, it means that the line is________.

TESTING, DIAGNOSIS, AND TROUBLESHOOTING

In this session, you will learn some of the principal things you should check so that you can determine rapidly whether you have data terminal trouble or line facility trouble. Included at the end is a chart to aid you in taking the proper sequential actions in approaching a teleprocessing service problem.

Highlights:

- Initial information to be gathered
- Testing at the interface
- Data Set tests
  - By common carrier (End-to-End)
  - By IBM
- Published service aids
- Teleprocessing service practices
- Measuring peak jitter and distortion

Up to this point you have been learning the basic concepts of telephone communication together with the associated equipment necessary for implementation - both for voice and for data. Many new terms have been introduced. Some of the terms have been defined while others have been introduced and defined only by their contextual use. For each session of this course, there have been sessional descriptions and highlight listings. Essentially, these comprise the objectives of studying each session. Now, you will have to become acquainted with some new approaches to troubleshooting where, in many cases, you will not be able to circuit trace or scope down to the failing component but must, based on the background developed through this course, make sound decisions as to the source of trouble when that source may not be in our equipment nor at a location where you can directly observe it. This means you will have to observe indications at the interface between the data terminal equipment and the communication facility, and, based on your newly developed background, deduce the most likely source of trouble.

Except when the IBM Line Adapter is used, you will not be able to scope the signals on the communication lines. This means that if you suspect line problems, you must establish that point from observing conditions presented on the interface. The problem is somewhat like a doctor who establishes the need for surgery based on symptoms disclosed by the patient, his own observations, and X-rays. Your X-rays are the oscilloscope presentations available at the interface.

In this session, we will be dealing with two areas of troubleshooting: testing and diagnosis. One area is the province of IBM while the other belongs to the Common Carrier, the dividing line being the INTERFACE.

INITIAL INFORMATION NEEDED

Before you really worry about establishing responsibility for service in a data communications complex, there are several items of information you should obtain from the customer. These items include:

1. Number of error and/or retry attempts.
2. In multiple line systems, on what line did the error occur.
3. Which terminal on the line was being worked.
4. What terminal component (reader, punch, keyboard) was in use at the time the error occurred.
5. What mode of operation (send or receive) was being employed when the error occurred.
6. What was the local time, and the remote terminal time, at the time of the error occurrence.
7. Results of the Diagnostic Function Test (if one is available).

When you determine that coordination is necessary between both ends in order to isolate the trouble, you will require auxiliary communications with the remote terminal. The responsibility for providing this communication rests with the customer. Use the communications facilities as necessary to provide the required service but not wastefully. If, in dialing, a wrong number is reached, have the operator notified as you would at home so the customer won't be billed for useless calls. In many instances using customer-owned lines (dry pair), the IBM Sound-Powered Telephones may be clipped on the line according to a prearranged schedule for auxiliary communication.

TESTING AT THE INTERFACE

One of the most valuable tests you can make if receiving errors are being experienced is to scope the Received Data line at the interface and check for:

1. Mark/Space ratio.
   Should be unity or peak distortion less than 20%.
2. Correct code bit configuration for data.
3. Glitches and spikes on Received Data.
4. Voltage levels delivered.
   EIA data sets should yield a 3 to 25-volt swing from zero, plus for Space and minus for Mark, and data terminal should deliver 5 to 25-volt swing on leads to the data set.

Make sure interface line sequence is correct and that no glitches occur on Request to Send, Clear to Send, or Carrier Detect lines (others, if applicable to your terminal).

If the errors are in sequence as opposed to data, check that the features of the data set are responding correctly at the interface. Some important ones are:

1. Auto Answer
2. Initiate Disconnect
3. Respond to Disconnect

Some other methods which are useful in determining which way to go are:

1. Data Terminal Self Test.
2. Data Terminal Self Test including interface. (Requires a spare DB-19604-543 connector wired up to loop Transmitted data back to Received data and to condition necessary interface lines for terminal actuation for EIA Interface.) (Special connectors are necessary for Digital Interface. Some EIA cables have a switch in the terminal connector to accomplish this procedure.)
3. Data Terminal/Data Set loop back test (to be described later in more detail).
4. If noise is experienced, contact Common Carrier, as previously described in an earlier session, to perform tests. Note: Sometimes the Common Carrier can provide specially selected "quiet lines" for limited testing.
5. Compare peak distortion at the interface on Self Test/Data Set loopback with distortion when operating on-line.
6. Sometimes noisebursts may come from a "ringer" on line which is being triggered by certain data sequences which look like a "ringdown" signal to the "ringer". This problem requires careful analysis of the conditions under which the error occurs to determine the data combination producing the failure.

If the IBM Line Adapter is being used, other tests are applicable, which will be explained later.

DATA SET TESTING

This function may be divided into two areas: by Common Carrier and by IBM. This is the time to introduce the telephone company data test center as well as the Western Electric 901, 902, 903 test sets and the "End-to-End Test". In more instances, the CE's ability to test the data set is limited to full-duplex four-wire systems where our terminal has the ability to operate in a Self Test/Data Set Test mode. For this test, the terminal must be in Self Test/Data Set Test. This means all signals are routed through the interface and further that normal on-line clocking methods are employed. In addition, the loopback switch for the data set must be in the TEST position. See Figure 2-33. This switch connects the output of the sending portion of the data set to the receiving side through appropriate "loss pads" to simulate the proper received line level. The line is usually terminated in a resistive load so that it won't pick up

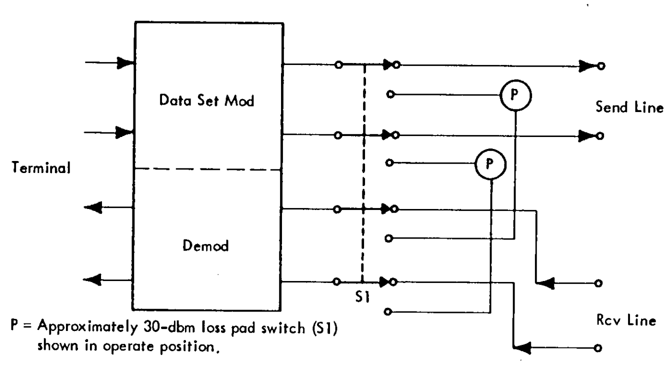


FIGURE 2-33. LOOPBACK TEST SWITCH

noise and disrupt normal operations of the users of telephone facilities. This switch may be located as:

1. Integral with data set.
2. Attached to data set.
3. Mounted to data set.
4. In a nearby room where the telephone equipment is mounted (large installations).

Sometimes the terminal can be operated in Self Test/Data Set Test with the loopback switch NORMAL, and the telephone company will provide "loopback" from various points along the line facility until the bad link is found. The conditions where this would be employed are:

1. Both terminals operate in Self Test/Data Set Test - local loopback.
2. Cannot work correctly on-line.

Measurement of Jitter

To determine whether Jitter is excessive, it is necessary to examine the Received Data line from the data set with an oscilloscope. Ideally, data bit transitions should occur coincident with either a data terminal clocking source or with the data set "clock." The actual transitions of data will be found to vary slightly from the "clock" transitions; this variation is "jitter." Up to 20 percent jitter can be tolerated, but more than 20 percent is considered excessive.

The transition of data which is furthest removed from the "clock" transition is the Peak Jitter. The suggested setup is to trigger the oscilloscope sweep on the Start bit leading edge for asynchronous applications (or the beginning of the receiving count on synchronous) and examine both the "receive clock" and the "Received Data" line as shown in Figure 2-34. The percent of jitter is equal to the maximum excursion of the data transition from the required point of transition divided by the length of a normal bit an multiplied by 100.

$$\text{Percent Jitter} = \frac{d}{D} \times 100$$

d = maximum excursion
D = normal bit length

Common Carrier 900 Test Sets

In cases where a new system is being implemented, the telephone company usually tests the line facility using the 900 series test sets along with the 904 Test Center. A picture of the 904 will be found in Teleprocessing General CEM #33.

At this point, an explanation of the use and capabilities of each of the test devices should be interesting. The tests to be described can be performed for most Western Electric data sets utilizing the EIA interface (EIA RS-232 or RS-232-A).

The 901 is an interface adapter to the data set designed to provide routine testing at the interface

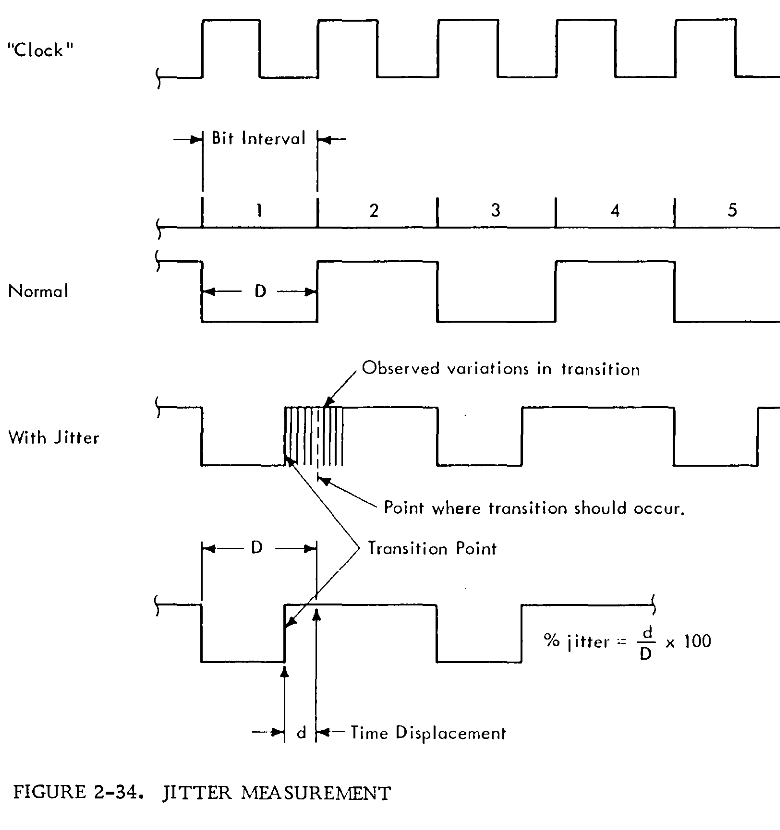


FIGURE 2-34. JITTER MEASUREMENT

independent of the data terminal. It can also monitor and measure the operating signal exchanged between the data terminal and the data set. See Figure 2-35 for a typical arrangement for use of the 901 in routine testing .

The 902 Test Set provides a means to measure peak distortion and detect transmission errors with serial data sets when used with the 903 Test Set.

A 63-bit binary word or an alternate Mark-Space pattern (dot cycle) may be generated by the 903 Test Set. See Figure 2-36 for a typical setup utilizing 901, 902, and 903 Test Sets, and 904 Test Center for conducting the "end-to-end" test.

When the 904 Test Center is contacted, the following tests can be performed:

1. Measure Modulator Mark frequency.
2. Measure Modulator Space frequency.
3. Check Output level of data set.
4. Check data set receive slicing level (threshold and limiter).
5. Check operation of Carrier Detector circuit.
6. Check operation of Request to Send circuit.
7. Check operation of Clear to Send circuit.
8. Check operation of Received Data circuit.
9. Check operation of Send Data circuit.
10. Check transmit level.

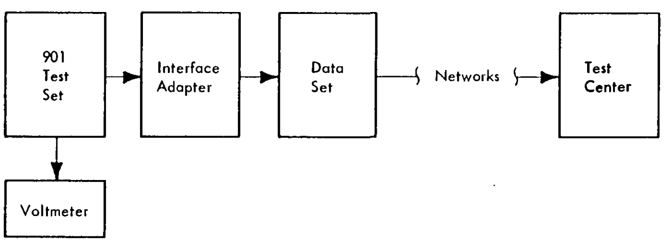


FIGURE 2-35. 901 TEST SET, HOOKUP

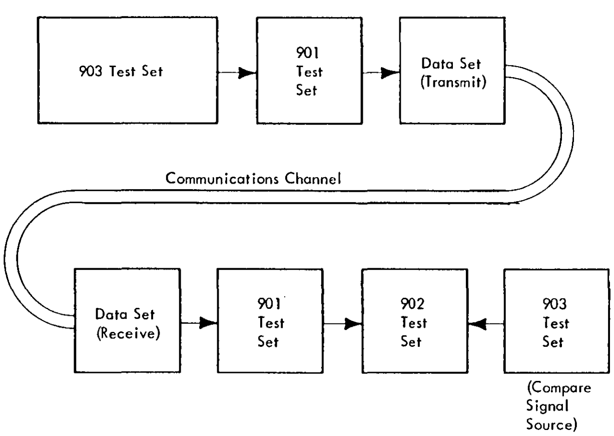


FIGURE 2-36. END-TO-END TEST HOOKUP

Summary and Reference

The following data set tests that may be performed:

1. Loopback test with Loopback Test Switch.
2. End-to-end dynamic test via 904 Data Test Center.
3. Local test (data set in Local) or loopback at data set connector.

When the IBM Line Adapter is in use, a System Simulator exists to perform comparable testing as outlined under the 900 series test sets. The Field Engineering Instruction Manual Form #225-3473 IBM Line Adapters includes complete information on this device and its use.

PUBLISHED SERVICE AIDS

Published service aids include those of IBM, the common carriers, and data set manufacturers.

The Bell System makes available Interface Specification books on each of the data sets it uses. These contain a wealth of information from basic description and options to theory of operation and operational cautions. The most significant of these have been covered under 100, 200, 400, and 800 series data sets in this course.

In the case of equipment manufactured by concerns such as RCA, General Electric, Automatic Electric, and Lenkurt (if your terminals interface with these devices), you can obtain information through your Area Communications Specialist or through FE Technical Operations (Service Planning Representative) at the plant of control for your data terminal.

Other sources of information within IBM include:

1. Teleprocessing CEM's - both General and those by specific machine type.
2. Technical Service Letters (TSL), particularly numbers G-10 and G-22. You should review these with your Field Manager as soon as possible so that you will understand the relative responsibilities of IBM, the customer and the common carrier.
3. IBM publishes manuals on the Line Adapter and also on the data sets used on WTC circuits such as the 3976 and 3977.
4. IBM Original Equipment Manufacturers Information (OEMI) booklets on machines such as the 1050, 2701, and a combined issue for 7701, 7702, 7710, and 7711. These provide a wealth of information concerning interfacing with common carrier facilities.

The text for this last session of Section 2, Asynchronous Data Communications, is concluded. You should be able to answer the review questions which follow by referring to the text. When you are ready, contact your course Administrator to take the evaluation examination. If your territory includes Synchronous Transmitter Receiver type data terminals, you should continue with the remaining sessions of this course. If you do not provide service for STR type terminals, you may skip the remaining material until your territory does include such devices. Regardless of the types of terminals you service, Chart 2-1 which follows provides a recommended sequence for handling a teleprocessing problem.

REVIEW QUESTIONS

1. List the four main things you can check at the interface between the data terminal and the data set. ______

2. In simplest terms, what does the loopback test switch on full duplex data sets do for the CE? ______

3. The 901 Test Set provides for operational evaluation of the data terminal. (True/False)

4. The End to End Test checks the telephone network as well as the sending and receiving ______ ______.

5. The 904 Test Center can measure many things regarding the operation of the data set at the request of the customer without the CE intervening. List five of them without reference. ______

6. What seven items of information should you try to obtain before trying to analyze the source of trouble? ______

7. If you are measuring "jitter" on the Received Data line, what would you use as a scope trigger in the case of a Start/Stop Terminal? ______

8. If the data terminal functions in Self Test, fails in Self Test/Data Set Test, but works properly when a bus-back (or loopback) is provided from a "down-line" point by the common carrier, what is probably wrong? ______

9. If you are experiencing noisy reception of Received Data on a dial-up line, what would be the first thing you would try? ______

10. Same conditions as previous question except on a leased half-duplex line? ______

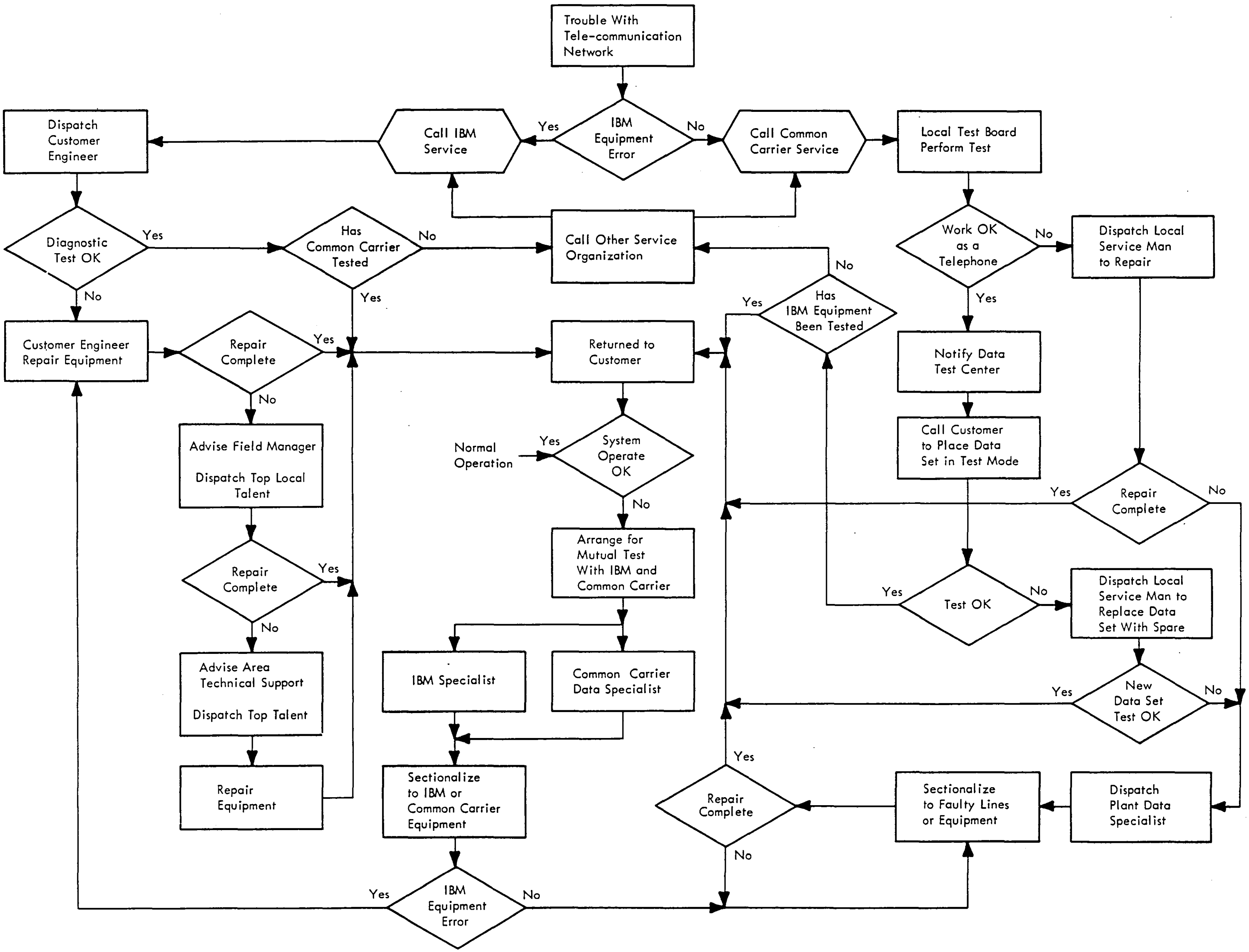


CHART 2-1. TELEPROCESSING SERVICE PRACTICES

SECTION 3

SYNCHRONOUS DATA COMMUNICATIONS

SESSION 1

SYNCHRONOUS FACILITIES

With Section 2 as background, this session provides information regarding data sets applicable to Synchronous mode of data communication.

Highlights:

- Digital Interface
- 202 type data set in synchronous operation
- Four-phase data set principles
- 201 type data sets with EIA interface to RS-232
- Additional interface lines
  DCT, SCT, DCR, SCR, NS

Synchronous facilities will be utilized by the following terminal types:

1. IBM 1009 Data Transmission Unit
2. IBM 1013 Card Transmission Terminal
3. IBM 7701 Magnetic Tape Transmission Terminal
4. IBM 7702 Magnetic Tape Transmission Terminal
5. IBM 7710 Data Communication Unit
6. IBM 7711 Data Communication Unit
7. IBM 2701 Data Adapter Unit
8. IBM 7740 Communication Control System
9. U.C.S.T.R. for 1240, 1401, 1440, 1460. and many other terminals employing the STR (Synchronous Transmitter Receiver)

As in the previous sessions, this operation will require common carrier communications channels and data sets.

In Section 2, Asynchronous Telephone, we covered AT&T Schedule 1, 2, 3 and 4 lines as well as Western Union Class A, B, C, D, E, and F lines. In general, this area deals with transmission rates above 600 bps, and extends to over 200,000 bps. This range of transmission rates calls upon the wideband services of the common carriers.

Data rates up through 2400 bps can be handled by facilities of Voice Grade (like Schedule 4 - with "conditioning"). Above 2400 bps, we leave the EIA interface and, by present practice, employ the Digital Interface.

DIGITAL INTERFACE

This section will deal with the Digital Interface as used by Western Electric data sets such as the 301. Most of the lines used are the same as the EIA interface but differ in signal levels and the required types of terminal to data set connectors. These differences will be covered under the 301 type data set. The most important difference is the use of current switching instead of voltage switching on the data leads of the interface.

DATA SET, WESTERN ELECTRIC TYPE 202

The Western Electric Data Set type 202 is frequently encountered in this service at bit rates of 600 and 1200 per second. This data set can operate up to 1800 bps on Schedule 4, type 4B or equivalent channels. As you will recall, the 202 did not possess the capability of supplying to the data terminal any clocking signals which are required to maintain bit phase and character phase. Therefore, if this data set is employed in synchronous service, the data terminal must provide the synchronizing clock signals. In

other respects, the material present in the previous section is applicable.

At this point a few words on synchronization for review purposes. Two types are required: Bit synchronization and Character synchronization. Normally, bit sync is the problem of the data set, or more specifically, of the clocking source. The term "bit sync" means that received bits are measured out on the same time base by which they are transmitted. Character synchronization is also called Character Phase and is the responsibility of the receiving and transmitting terminal equipment. Thus, if a character is measured out at the sending terminal by counting 1, 2, 3, 4, 5, 6, 7, 8 and then begins the next character at a count of "1" again, the receiving terminal must have a way of identifying when it is in step with the sending terminal so that a count of "8" at the receiving terminal means that a full character has been accumulated. The "idles" code 18R0 in 4 of 8 code is used by most synchronous IBM terminals to accomplish and maintain character phase. Special circuits continuously monitor the receiving circuits of the terminal and, whenever the 18R0 configuration is encountered, checks to see that the end of character count exists.

DATA SETS, FOUR PHASE

Four-phase data sets are most frequently encountered in processing high-speed serial synchronous data. The data sets can usually provide clocking to the data terminal to measure each bit precisely or, as an option, they may be controlled by the clock signal from the data terminal. (This is the method of providing and maintaining "bit sync" or "bit phase".)

The four-phase method of modulation makes it possible to obtain about one bit per second transmission rate per cycle of channel bandwidth.

For example: At 40,800 bits per second with a carrier frequency of 30.6 kcs, the actual transmission band would extend from 10.2 kcs to 51 kcs. This results in the ability to handle higher data rates on a given circuit than would be possible with FSK type data sets.

Now let's examine how the basic four-phase principle is employed to transmit data. (Refer to Figure 3-1.) For purposes of this explanation, consider a data signal of: 00 01 11 10 (the eight bits of a data character). Refer to the Table 3-1 for the dibit coding.

Further, if the 00 dibit is handled by the A channel of Figure 3-1, then while the carrier (shifted 5 x 45° or 225° relative to the previous dibit period) is being transmitted, the 01 dibit is being analyzed and the B channel is having its phase set. When the dibit clock signals the end of the first dibit period, the B channel will assume control of transmission. The phase change on the line will be gradual rather than instantaneous. This prevents splatter with its inherent spurious sideband frequencies.

TABLE 3-1. DIBIT CODING

Character	Dibit	Phase Shift
0 0	00	5 x 45°
0 1	01	7 x 45°
1 1	11	1 x 45°
1 0	10	3 x 45°

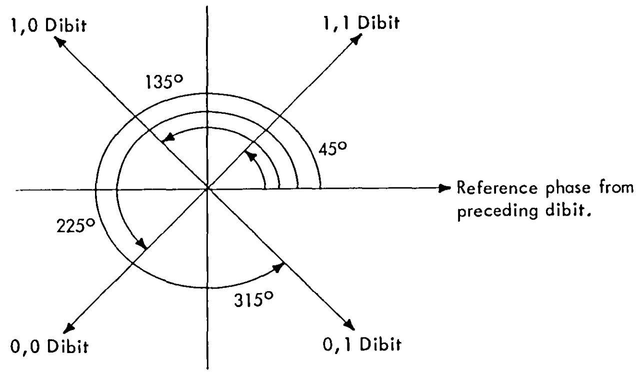
(NOTE: A dibit is a sequential pair of bits.)

While the 01 dibit is being transmitted as a phase shift relative to the 00 dibit, the A channel is setting up to transmit the 11 dibit. When the dibit clock signals the end of the 01 dibit, the controls will switch again and the A channel will provide the line signal. Note that the dibit clock runs at one half the frequency of the transmit clock. This means one cycle of the dibit clock requires the serial time of two bits.

Now let's examine the basic concepts of receiving a four-phase signal. Refer to Figure 3-2. As each dibit is received, it is detected and also transferred through a delay block. Thus, the signal out of the delay block always represents the phase of the dibit preceding the one being delivered at the output of the discriminator. The phase of the new dibit is compared with the dibit from the delay line to determine whether the new dibit is 00, 01, 11, or 10, and then the dibit is placed in the data register. The Receive Clock (running at twice the dibit frequency) gates the bits out serially to the Received Data line.

If a more detailed description of the carrier generation and detection principles of a four-phase data set is desired, two sources are available:

1. "Data Sets 201A and 201B Interface Specifications" - September 1962 available from American Telephone and Telegraph Company.
2. "PM Data Sets for Serial Transmission at 2000 and 2400 Bits per Second" by P. A. Baker, of the Bell Telephone Laboratories. AIEE Transaction Paper #62-143.



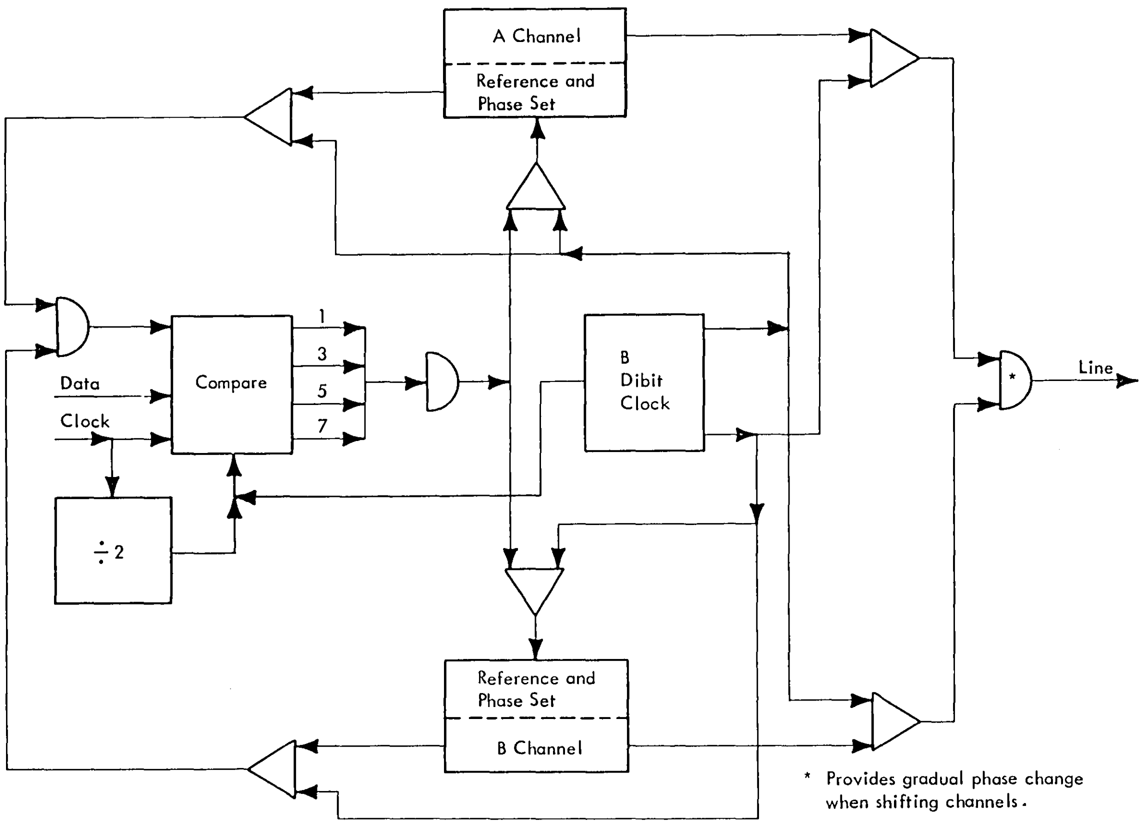


FIGURE 3-1. FOUR PHASE DATA SET - TRANSMIT CONCEPT

Now we are ready to examine the manner in which four-phase data sets are interfaced to data terminals utilizing Synchronous Transmission.

DATA SET - WESTERN ELECTRIC TYPE 201

The 201 Data Set operates basically as outlined in Section 2. Several lines exist in the interface for this data set which were not necessary for FSK types. The 201 essentially follows RS-232 (which is the contact closure version). Twenty-one of the 25 pins of the DB19604-432 connector are, or may be, used.

The main differences between the 201A and 201B are the bit rates and carrier frequencies used. These are listed in Table 3-2.

TABLE 3-2. 201A/201B CHARACTERISTICS

Set	Bit rate (bps)	Carrier cps
201A	2000	1750
201B	2400	1800

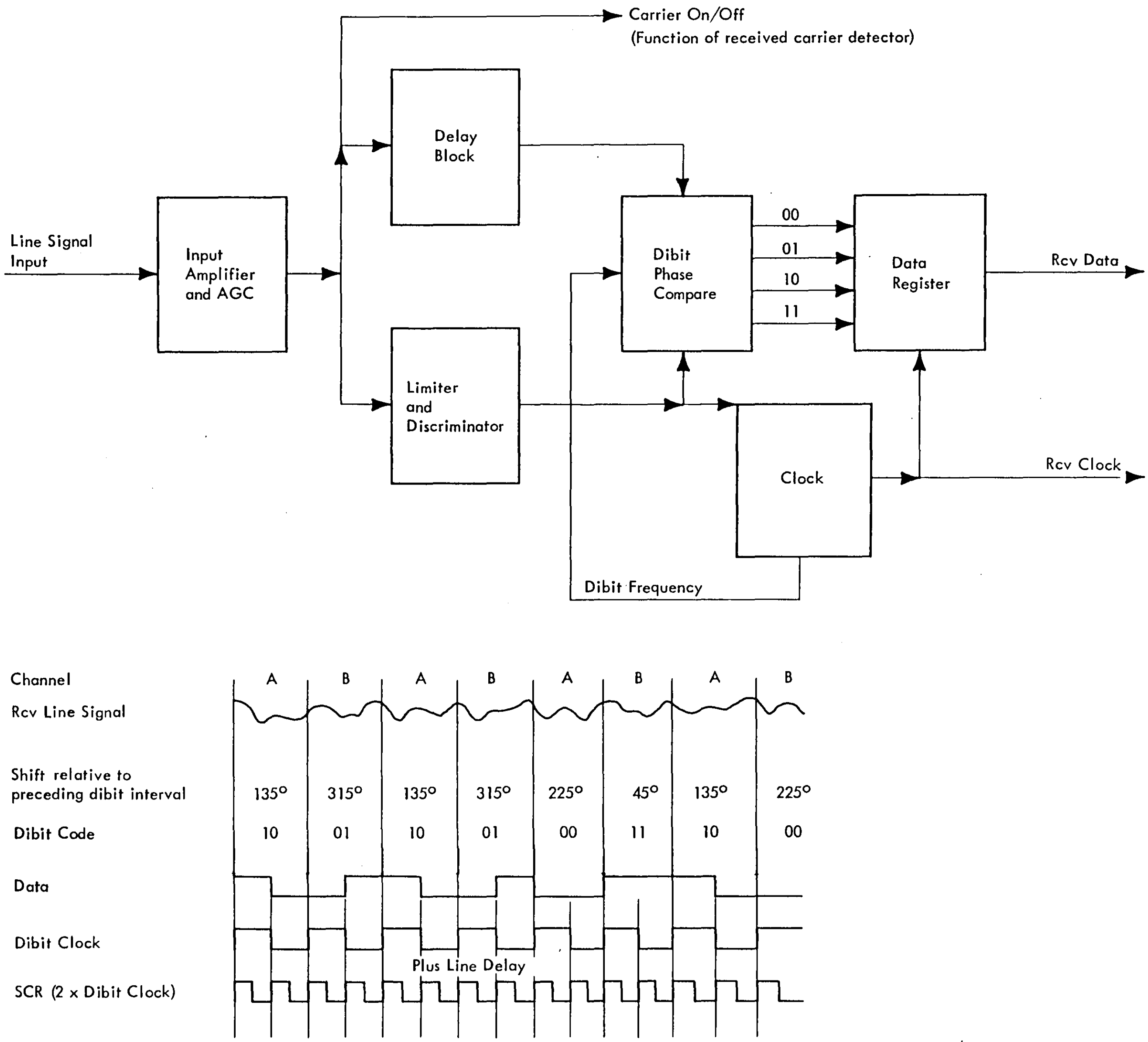


FIGURE 3-2. FOUR PHASE DATA SET - RECEIVE CONCEPT AND TIMING

The 201A will operate over dial-up telephone circuits or leased lines. The 201B is intended for use on leased lines. Both sets can be connected for two-wire or four-wire operation. Automatic Answer option is also available.

The half duplex operation on a dial-up two-wire facility will be used as an example. When it is desired to transmit, the Request to Send line must be turned On (swing from - to +). When the data set is ready to send data, the Clear to Send line will be returned to the data terminal equipment. As soon as the Request to Send line is On, the data set begins sending repeated 11 dibits. The receiving data set:

1. Receives carrier and conditions Carrier On.
2. Receiver supplies clock signals both at data rate and dibit rate.

The 11 dibit, rather than 00 or 01, is repeated under idling conditions, because there is less jitter in the recovered signal from the repeated 11 dibit. Then, as in other EIA data sets, the line will be Marking during the period from the On condition of Request to Send until the On condition of Clear to Send.

Clear to Send will normally turn On 150 milliseconds after the issue of Request to Send. This means that the remote data set will be receiving repeated 11 dibits for at least 150 milliseconds and

therefore has adequate time to condition Carrier On, recover carrier, and establish bit phase timing from the repeated 11 dibits. Note that in these four-phase data sets, there is no permanently stored reference phase. Each dibit is referenced to the one immediately preceding it.

When Clear to Send turns On, the data terminal may begin gating data to the data set. The bits should be presented coincident with the rise (+) of the serial transmit clock and sampled at the fall of the serial transmit clock.

When the Request to Send line falls, the Clear to Send line also falls, but the carrier generator continues transmitting for 2 milliseconds to clear the last dibits before turning Off the transmit function and turning On the receiver.

The 150-millisecond delay between Request to Send and Clear to Send is called the "Echo Delay" option and is provided by internal strapping of data set circuits. The Echo Delay option also keeps the receiver turned off for the first 100 milliseconds after the transmit function is terminated. This allows line echoes time to dissipate before the receiver is turned on.

When fast turn-around time is required and the two-wire lines are very short, or where the data terminal has the ability to discriminate against echo responses, the Echo Delay option may be strapped out. Under this mode of operation, if Request to Send issues coincident with the rise of the Dibit Clock Transmit, turn-around may be accomplished in minimum time. Clear to Send will turn on 8-1/2 $\pm$1/4 milliseconds from issue of Request to Send. See Figure 3-3.

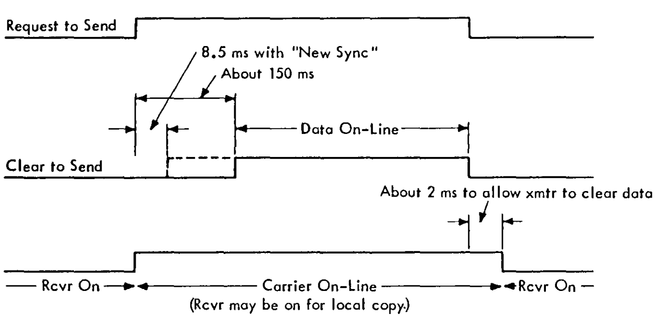


FIGURE 3-3. TURN-AROUND TIME

INTERFACE

See Table 3-3 for explanation of interface pin assignments.

Some interface lines require comment and will be covered here.

TABLE 3-3. 201 INTERFACE LINES

Pin	Name	Abbreviation
1	Frame Ground	G
2	Send Data	SD
3	Receive Data	RD
4	Send Request	RS
5	Clear to Send	CTS
6	Interlock	IT
7	Signal Ground	DG
8	Carrier On - Off	CO
9	+Power	
	reserved Telco Test	
10	-Power	
11	Not Used	
12	Not Used	
13	Not Used	
14	New Sync	NS
15	Serial Clock Transmit (or external timing input)	SCT
16	Dibit Clock Transmit (not available with external timing)	DCT
17	Serial Clock Receive	SCR
18	Dibit Clock Receive	DCR
19	Remote Release	RR
20	Remote Control	RC
21	Ready	RDY
22	Ring Indicator 1	RG 1
23	Ring Indicator 2	RG 2
24	External Timing Input (see Note)	
25	Not Used	

NOTE: Some 201A and B Data Sets manufactured after October 1962 have pins 15 and 24 connected internally. These sets may be identified by the ink stamping on the bottom. Either J1D201A-1 L1--- B- or J1D201B-1 L1---B- have pins 15 and 24 connected. Thus, if a data terminal providing a business machine clock is connected to a data set of this series having a data set clock, one will beat against the other, creating an impossible condition for synchronous data transmission. Later sets will have 15 and 24 separated.

Interlock line (pin 6) provides a +6-volt level when the data set is operational. Zero volts indicates nonoperational status.

As with other EIA data sets, the SD and RD leads represent a Mark as negative and a Space as positive.

Carrier On changes from negative to positive within 9 milliseconds of arrival of the carrier at the receiver.

Serial Clock Receive is derived by the data set from the line signal. Each bit delivered to the data

terminal is signaled by the rise (+) of SCR and it is recommended that terminal sampling be performed coincident with the negative transition of SCR. See Figures 3-4 and 3-5.

Impulse noise between the business machine ground and data set ground should not exceed a peak value of 1 volt.

OPTIONS

When 201 Data Sets are used on a multi-drop line, the new Sync feature may be used. A 1-millisecond positive pulse applied by the terminal to pin 14 permits the data set to "forget" previous bit phasing and re-establish sync on a new carrier within 8-1/2 milliseconds. If this feature is not desired, it must be jumpered out by internal data set strapping (part of original system planning with Telephone Company).

A contact closure is provided between Ring Indicator leads RG1 and RG2 during the "ring" if Auto Answer option is used. To answer an incoming call, assuming Remote Release (RR) and Remote Control (RC) leads are connected together, the terminal connects Ready to Remote Release and holds this condition throughout the contact. To go "on-hook", the terminal should open RR to RC for at least 150 milliseconds. If RR and RC are not connected, data set cannot get into Data mode. An alternate method of termination may be provided by opening Ready lead, but requires more time.

Where 201 Data Sets are used on four-wire lines, a test loopback switch similar to that shown in Figure 2-33 will be provided.

The text for this session is concluded. Using the text as a reference, answer the following review questions before proceeding to the next session.

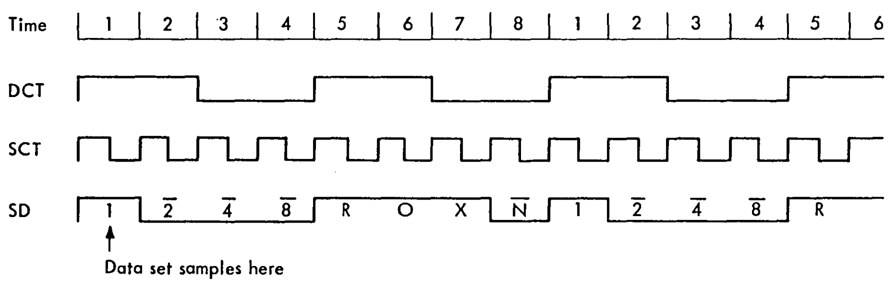


FIGURE 3-4. RELATION OF DCT, SCT, AND SD

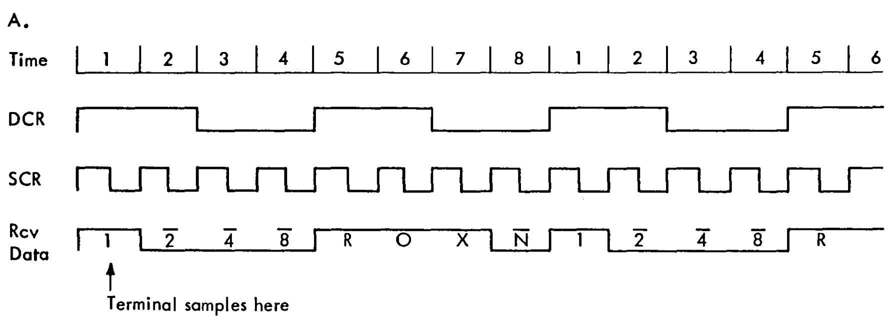


FIGURE 3-5. RELATION OF DCR, SCR, AND RD

REVIEW QUESTIONS

1. How does the Digital Interface differ from the EIA Interface as far as the Send and Receive Data leads are concerned? ________________
____
____

2. The 202 Data Set provides "clocking" to the data terminal. (True/False)

3. What is meant by the term DIBIT? ________
____
____
____
____
____
____
____
____
____

4. If an "A" is being transmitted in 4 of 8 code through a four-phase data set, what phase shift will the dibit comprising the XN bits produce relative to the reference established by the RO dibit?

5. If the Dibit Phase Compare circuit of Figure 3-2 decodes a 315° phase shift, what dibit code will be placed in the Data Register?

6. When the 201 Data Set has Request to Send up but no data is being delivered, what dibit code is repeated on the line?

7. Carrier On means the local carrier is being generated in a 201 wired for FDX operation. (True/False)

8. What is the frequency ratio of SCT to DCT?
____

9. If no options are employed, how long after the issue of Request to Send will Clear to Send turn On?

10. How long does the 201A keep transmitting after the fall of Request to Send? Why?
____

11. If Echo Delay is strapped out and New Sync is used, how long after the rise of Request to Send (coincident with the rise of DCT) will Clear to Send turn On? ________________

12. Data Set 201 is wired for (RS-232/RS-232-A).

13. If a 201 Data Set with interface pins 15 and 24 internally connected and having its own clock connected to a data terminal which expects to supply the data clocking, what will happen?
____
____
____
____
____
____
____
____
____
____
____

14. A logical 1 bit is presented to the 201 on the Send Data line as a (positive/negative) voltage.

15. Bits are supplied to the data set coincident with the rise of SCT. When does the data set sample the bit relative to SCT? ____________
____

DATA SETS - 300 SERIES

This session will familiarize you with the changes in interface between EIA and the Digital Interface.

Highlights:

- Digital Interface
- Idle condition coding 1000 with 301 compared with 11 for 201 Data Set
- Loopback test
- Mark is less than 5 ma or about 0 volts.
- Space is greater than 23 ma or about +2 volts.

The 301 Data Set differs from the 201 in speed and interface. The 301B Data Set is intended for operation at 40,800 bits per second, while the 301C is for 18,000 bits per second, utilizing wideband facilities. Data sets of this family require the so-called Digital Interface. The Digital Interface employs current switching. The cable for this interface may not exceed 50 feet and should be terminated with a Burndy Number MB12XP-3TC plug. See Table 3-4 for lead definitions.

TABLE 3-4. DIGITAL INTERFACE

Pin	Name	Abbreviation
A		
B	Dibit Clock Transmit	DCT
C	Clear to Send	CS
D	Send Request	SR
E	Send Data	SD
F	Interlock	IT
G		
H	Serial Clock Transmit External	SCTE
J	Serial Clock Transmit (Int)	SCT
K	Received Data	RD
L	Serial Clock Receive	SCR
M	Carrier On - Off	COO
N		

Several other differences exist between the 301 and 201 because of the use of the Digital Interface. These are:

1. Idling send condition (coding)
2. Request to Send/Clear to Send timing
3. Signal Levels

The 301 series Data Sets are usually used with the Telpak line facility. The interface specification states that short runs over twisted pair with wideband repeater amplifiers is permissible. Telpak-A is of the Type N carrier service. This service has AGC functions in the line equipment which would be adversely affected if any repeated line signal other than 1000 is used (remember, 11 was used with 201). Since this condition exists, bursts of IBM Idles in 4 of 8 code (18RO) must be kept short to minimize interference, and, whenever the 301 is not sending data (Request to Send On), the data set generates and transmits a repeated 1000 signal. This restriction also applies when the Telpak facility is part of an L1 multiplex carrier system. The signals from the 301B occupy the line spectrum from 10.2 to 51 kc to transmit 40.8K bps.

When Request to Send is Off, the 301 transmits 1000 repeatedly. When Request to Send is turned On, Clear to Send will turn On immediately (within 1 microsecond). This means that the present 1000 sequence being processed will not be completed but will give way to data. When RS is turned Off, the fall should be at the same time as the positive shift of SCT which occurs after the last data bit. The data bit on the line and their relation to SCT is the same as for the 201. See Figure 3-4.

The high-speed data transfer on the Send Data and Receive Data lines utilizes current switching. The same mode is also used on the other interface lines. An Off condition is defined as less than 5 ma of current flow into a load of 100 ohms, while an On condition is defined as greater than 23 ma into a 100-ohm load. In the case of the 7711 DCU, signals are about 0 volts for a Mark and about +2 volts for a

Space on our side of the interface. A loopback test key is provided for use with this data set. The output of the modulator will feed the input of the modulator through a 30-dbm loss pad, and the unused communication line will be terminated with a 135-ohm resistive load to prevent noise. The box containing the switch also is provided with six jacks reserved as follows: (for common carrier testing)

1. Two are for line test toward the telephone central office.
2. Two are for tests from the office to the data set.
3. Two are for monitoring line signals under data conditions.

These same facilities are available either through the telegraph or the telephone common carriers.

This completes the coverage of common carrier facilities peculiar to synchronous data transmission. Answer the review questions using the text as a reference and then contact your course administrator to take the final examination. This will complete your course on Common Carrier Facilities for Teleprocessing.

REVIEW QUESTIONS

1. The fixed data rate for the 301B Data Set is ________ while that for the 301C is ________ bps.

2. The 301 Data Sets utilize the ________ interface which employs ________ switching instead of ________ switching as is used in the 201 Data Sets.

3. The repeated idling code transmitted by the 301 Data Sets is ________.

4. Why can't IBM Idles (18RO) be used as the repeated idling code for the 301? ________

5. What channel facility is required for operation with the 301B? ________

6. How are Mark and Space conditions represented on the interface? ________

7. What voltage level (approx) will be observed of a Mark and a Space respectively? ________

8. How long after Request to Send is issued will it be until Clear to Send turns On? ________

9. What are the purposes of the six jacks on the loopback switch box? ________

10. The current 1000 signal will be completely processed after Request to Send before Clear to Send will turn On. (True/False)

ANSWERS TO REVIEW QUESTIONS: SECTION 1

SESSION 1

1. 62.5
2. Current
3. Regeneration repeater
4. Receive Only Typing Reperforator
5. A TD (Transmitting Distributor) provides a piece of equipment to transmit the data of a previously punched telegraphic tape to the line. It is a "tape reader."
6. The receiving polar relay points follow the transmitted data signal and may be used for local monitoring or checking purposes.
7. Jitter, fortuitous
8. Characteristic
9. Spacing end
10. Marking bias
11. Shortened
12. Capacitance, inductance
13. Crossfire
14. Marking end
15. 35

SESSION 2

1. Stunt box
2. Function generator
3. Polling
4. Addressing
5. The message (traffic)
6. "V"
7. Call Directing Code, Transmitter Start Code
8. TSC
9. One
10. FIGS, H, LTRS

SESSION 3

1. True (62.5 ma $\pm$ 2.5 ma)
2. One, One
3. 31.25
4. 20
5. Scope the output at the receive polar relay points while sending.

ANSWERS TO REVIEW QUESTIONS: SECTION 2

SESSION 1

1. a. transmitter, b. receiver, c. switch hook contacts, d. induction coil, e. ringer
2. a. Match impedance of transmitter to line.
   b. Match impedance of receiver to line.
   c. Match line impedance which prevents dc in transmitter circuit from flowing in receiver circuit.
3. 20
4. arrestor box
5. 600
6. loading
7. a. 1
   b. 3
   c. 4
   d. 6
8. To provide power to operate system relays and indicators under control of the telephone instrument.
9. open, twisted
10. tuned reed

SESSION 2

1. 10,000
2. pulses, step-by-step, panel, crossbar
3. dc supervisory circuits
4. c
5. True
6. True
7. computer

SESSION 3

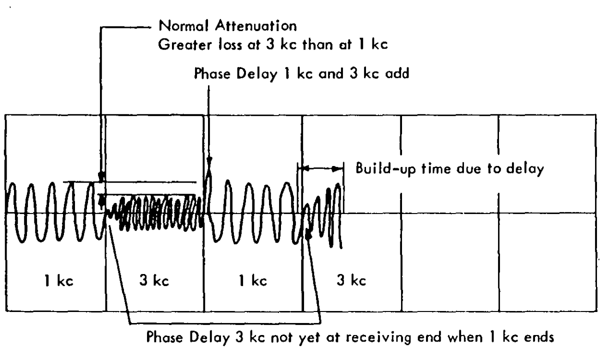
1. Direct Distance Dialing
2. 5
3. 7
4. Control Switching Points (CSP)
5. False
6. False. The Class 4 office may be a Toll Center or a Toll Point. If it is a 4C (Center), it will handle Inward, Outward and Through traffic. If, instead, it is a 4P (Point), it will only handle Outward and Through traffic. Inward comes from Class 3, Outward comes from Class 5.

SESSION 4

1. a. Open Wire, b. Toll Cables, c. Carrier Systems
2. multiplexing
3. 12, 48
4. 7,440,000 cps (7.44 mc)
5. a. Telegraphic grade
   b. Subvoice grade
   c. Voice grade
   d. Wideband
6. 600
7. N
8. 240
9. Wideband
10. Telpak C (equivalent of sixty 4-kc voice channels = 240-kc bandwidth)

SESSION 5

1. Attenuation is the loss imparted to signals traversing a given line and is affected by line materials, impedance matching, and frequencies being transmitted. Thus, if a 1000-cycle and a 3000-cycle signal were being transmitted alternately, we could expect the received level of the 3-kc signal to be less than that of the 1-kc signal, but no change in the periods (that is, each would last 5 ms). In the case of phase delay, the 1000-cycle signal would travel faster than the 3000-cycle signal. Thus, the 1-kc signal would "catch up" with the 3-kc signal and algebraically add at the receiving end while the 3-kc signal following the 1-kc signal would lag and a "no-signal" condition would prevail for a short period following the 1-kc "tail". See the figure below for an example of how this would appear on an oscilloscope.



2. phase delay
3. a. Crosstalk
   b. White noise
   c. Impulse noise
4. True
5. False
6. increase
7. increase
8. impulse

SESSION 6

1. repeater, hybrid
2. echoes
3. echo suppressor
4. True
5. No. Since Ⓐ is about -9 dbm and Ⓑ is about +3 dbm, the inserted signal will be at a lower level than that for which the line is designed. In fact, for satisfactory operation, some amplification would have to be introduced between Ⓐ and Ⓑ.
6. C1
7. impedance
8. Compandor
9. noise or crosstalk

SESSION 7

1. Customer Owned And Maintained
2. 60, 75, 100
3. 4, 4A, 4B
4. Line Adapter
5. wideband
6. relay
7. to convert signals originating at the data terminal into a form acceptable to the channel when sending.
   to convert signals from the channel to a form acceptable by the data terminal when receiving.

SESSION 8

1. CCITT (International Consultative Committee on Telephone and Telegraph)
2. RS-232, RS-232-A
3. a. Request to Send
   b. Clear to Send
   c. Send Data
   d. Received Data
   e. Interlock
4. Received Data
5. Power on and operationally ready conditions of data set.

SESSION 9

1. Each of the shared line adapters has a different subchannel. Thus, while one pair of terminals is communicating by using frequency shifts from 820 to 990 cps, a second

set could be communicating utilizing 1230 to 1400 cps, #3 using 1640 to 1810 cps and #4 set with 2050 to 2250 cps. These frequencies, you will note, do not cross each other's ranges and do not produce intermodulation beat notes which could cause interference between them.

2. 150, 600 (generally but 134.49 or 180 is also acceptable as an answer in place of 150).
3. a. 1400, b. 1810
4. False
5. False
6. True
7. Mark
8. Mark (because of action of Threshold or Line Clamp circuit when signal falls below previously selected -21 dbm to -27 dbm level).
9. 12.5
10. To allow the transmit oscillations and line echoes to die out or decay.
11. True
12. Phase delay. Note that slow high frequency and fast low frequency "catch up" with each other on the line during a Space to Mark transition and add algebraically.
13. $\pm$ (positive)
14. $\mp$ (negative)
15. $\mp$ (negative)

SESSION 10

1. 2025, 2225, 1070, 1270
2. True
3. True (provided data terminal is ready)
4. 200
5. Auto Answer is selected at data set.
6. echo suppressors
7. (a) W; (b) Z; (c) X, Y
8. RS-232, RS-232-A
9. CY
10. Mark, -, OFF
11. 265
12. 50
13. "on-hook"
14. Yes, EIA RS-232-A requires that the data terminal accept $\pm$ 3-volt signals.
15. EIA, UNI-Polar, Current (60 ma)
16. False - Answering data set sends F2M or 2025 cps when DATA key is depressed. DATA key performs Request to Send function.
17. a 3-second period of Space frequency carrier.
18. False - Common Carrier reserves a 2-volt margin, which requires that signals on Send Data lead must swing <u>at least $\pm$ 5 volts</u>.

SESSION 11

1. 1800 bps
2. 202A and B are wired to RS-232 while 202C and D are wired to RS-232-A (option available to provide RS-232 for 202C and D)
3. Multivibrator may saturate and fail to oscillate; thus no carrier is produced.
4. Interface leads 19 and 20 accept a contact closure to answer a call if RS-232 is used. In most IBM applications, they are strapped together in the interface connector (DB-19604-432).
5. 200
6. False - Data set must be in Data mode to have Interlock On.
7. True - If so ordered, the telephone company will provide a 202C or D wired to work with RS-232 until further notice.
8. When a 202 is connected for half-duplex operation, the Send Data line is repeated on the Received Data line after passing through the interface and being returned by the data set.
9. 20% (summation of characteristic distortion and peak jitter)
10. Schedule 4 - type 4A - maximum bit rate 1400 bps. Note that 4B may also be used but would be more expensive, while type 4 is not recommended above 1000 bps.

SESSION 12

1. parallel
2. 20, 3 out of 14
3. d
4. character separator (no closures)
5. left-hand switch hook contact button in telephone cradle. Pull up to place in Data mode.
6. grounded
7. a
8. 401H handles numeric information only in 2 out of 8 code and can be conditioned at the interface for serial bit transmission. 401E handles alphameric data in 3 out of 14 code.
9. 8 levels up to 75 characters per second
10. X403A
11. PND, 5
12. DPR, 2
13. CRQ, 4
14. DSS, 13
15. ACR, 3
16. 801 will go "on-hook" and cancel the call unless option Z is installed (EON) and DSS has already turned On.
17. busy (probably an error condition or bad programming)

SESSION 13

1. a. Mark/Space ratio
   b. code bit configuration
   c. glitches and spikes on Received Data line.
   d. voltage levels -2-volt margin
      5 to 25 volts on lines to data set
      3 to 25 volts on lines from data set
2. The loop-back switch transfers the output send line of the data set through an appropriate loss pad to the input receive line of the data set. This bypasses the communication network and makes it possible to check transmit and receive data set operation at the data terminal interface.
3. False. It is intended for normal "out of service" testing.
4. data sets
5. Modulator Mark frequency
   Modulator Space frequency
   Modulator Output level in dbm
   Threshold receive level
   Carrier Detect circuit
   Request to Send circuit (causes emission of carrier)
   Clear to Send circuit
   Received Data circuit
   Send Data circuit
6. a. Number of errors encountered and number of retrys.
   b. Line (communication) on which error occurred.
   c. What terminal was being "worked" - or is it all terminals.
   d. What terminal component was in use or is the problem common to all components.
   e. Send or Receive or both.
   f. Local time of occurrence and time zone of failing terminal (if different).
   g. Results of any Diagnostic Function Tests (either as part of customer program or IBM tests).
7. The leading edge of the start bit as determined by the receive bit counter of the terminal.
8. No loss pad in Send to Receive jumper legs of loopback switch or else wrong size loss pads (either too great or too little).
9. Dial again (several times) since due to the normal circuit selection methods of telephone equipment, you stand a pretty good chance of getting a different line configuration to the remote terminal.
10. Request a new line - usually available unless "special conditioning" has been provided.

ANSWERS TO REVIEW QUESTIONS: SECTION 3

SESSION 1

1. Digital interface uses current switching instead of voltage switching as in the case of the EIA interface.
2. False. Any "clocking" required for bit length or synchronizing control must be provided by the data terminal.
3. A Dibit is a sequential pair of bits whose relative status (00, 01, 10, or 11) is used to set the carrier phase of a four-phase data set. This provides a means whereby the actual number of frequency changes on the communication line is only 1/2 of the bit rate since only one phase change is imparted for each pair of bits.
4. 135° (3 x 45° - see Figure 2-36)
5. 0, 0 (7 x 45° = 00 dibit)
6. 11
7. False - Carrier On in a FDX 201 means remote carrier is being Received.
8. 2:1 (Dibit clock runs at 1/2 SCT rate so bits can be "paired".)
9. 150 milliseconds
10. 2 milliseconds (to process the last dibit delivered on SD)
11. 8-1/2 milliseconds ± 1/4 millisecond
12. RS-232
13. The two clocks will beat together, resulting in the original frequencies together with sum and difference beats - this makes it impossible to hold character phase. Sometimes character phase will be established by the terminal but then will be immediately lost again. It depends on how close the two clocks are to the same frequency.
14. negative
15. at the fall of SCT, or the midpoint of the bit period.

SESSION 2

1. 40,800 bps, 18,000 bps
2. Digital, current, voltage
3. 1000
4. A repeated code other than 1000 tends to interfere with the AGC action of the carrier facilities employed.
5. Telpak A2 (or twisted pair plus wideband amplifiers for very short distances)
6. Mark = Off = less than 5 ma
   Space = On = greater than 23 ma
7. Mark = 0 volt
   Space = +12 volts
8. less than 1 microsecond
9. a. 2 for line tests <u>to</u> central office
   b. 2 for line tests <u>from</u> central office
   c. 2 for local monitoring of line signals
10. False

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Telephony Goes Electronic. "Electronics", Volume 37, No. 27, October 19, 1964. This is a primer of the New Electronic Switching system as well as a summary of Manual, Step, Panel, and Crossbar Switching. Reprint #R-62 is available from Electronics Reprint Department, 330 West 43rd Street, New York City, New York 10036. Price: 50 cents.

Teletypewriter Fundamentals Handbook. Interesting booklet setting forth concepts of TTY transmission and reception, including pictures of equipment. By: William D. Rexroad. Copyright 1965 by the Computer Design Publishing Company, West Concord, Massachusetts. Available from: Computer Design Publishing Company, Baker Avenue, West Concord, Massachusetts, 01781. Price: $1.50

Planning and Installation of a Data Transmission System. Form A24-3435. Excellent source of data concerning line constants IBM Line Adapters, etc.

IBM Line Adapters (Modems). Form 225-3473. Manual of Instruction on all current IBM Line Adapters.

1410 Telecommunications Manual. Form A22-0525.

7701, 02, 10, 11 Original Equipment Manufacturers Information. Interface lines to some types of data sets, connectors, etc. Form A22-6818.

2701 Original Equipment Manufacturers Information. Form A22-6844. More information of various data set interface lines including auto dial type.

Data Communications Handbook IBM. Form Z20-1939 Currently includes the following publications in addition:

a. Terminal Equipment. Form Z20-1723
b. Use of Communication Facilities in the Design and Implementation of Tele-processing Systems. Form Z20-1700
c. IBM System/360 Tele-guide. Form Z20-1702.

The handbook contains resumes of tariffs filed with FCC by AT&T and WU that are pertinent to data communications. Data Sets and other interface devices of the Common Carriers are also described. The System/360 Tele-guide contains a wealth of information on configuration, features, and facilities.

IBM Tele-Processing Bibliography. Form A24-3089. A further source of titles not included in this listing.

Bell System Data Communications Technical Reference Manuals. These booklets are published by AT&T and are available retail through your local Graybar Electric Company Sales Office. Price is $1.50 each, minimum order $5.00. The available subjects are:

- Bell System Data Communication Services
- Data Set Interface Connectors
- Data Set 103A Interface Specification
- Data Set 103B Interface Specification
- Data Set 201 A/B Interface Specification
- Data Set 202 A/B Interface Specification
- Data Set 301B Interface Specification
- Data Set X301C Interface Specification
- Data Set 401 A/B Interface Specification
- Data Set 401 E/F Interface Specification
- Data Set 402 A/B Interface Specification
- Data Set 602 A Interface Specification
- Data Set 801 A, B, C

The manuals on data sets contain good operating descriptions as well as information about electrical specifications. A loosefeaf binder to hold such manuals is also available.

Principles of Electricity Applied to Telephone and Telegraph Work. Published by American Telephone and Telegraph Company - latest edition 1961. This is a basic text on elementary electrical principles for internal training at AT&T. We find it particularly helpful on telephone and telegraph principles, telephone transmission theory, modulation, and carrier. It is available in many libraries, public and IBM, and from Graybar for approximately $4.20.

EIA Standard. Form # RS-232-A, published by the Engineering Department, Electronic Industry Association. Describes the interface between Data Processing Terminal Equipment and Data Communication Equipment. Available from EIA Engineering Department, 11 West 42nd Street, New York 36, New York. Price: $.90.

Communication Network Design Programs. Form Z20-0310. Aid to design of low cost message control and data transmission systems.

Introduction to Visual Displays. Form Z20-1709.
IBM 7770 - IBM 7772 Audio Response Units Information for Common Carrier Equipment connection.

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