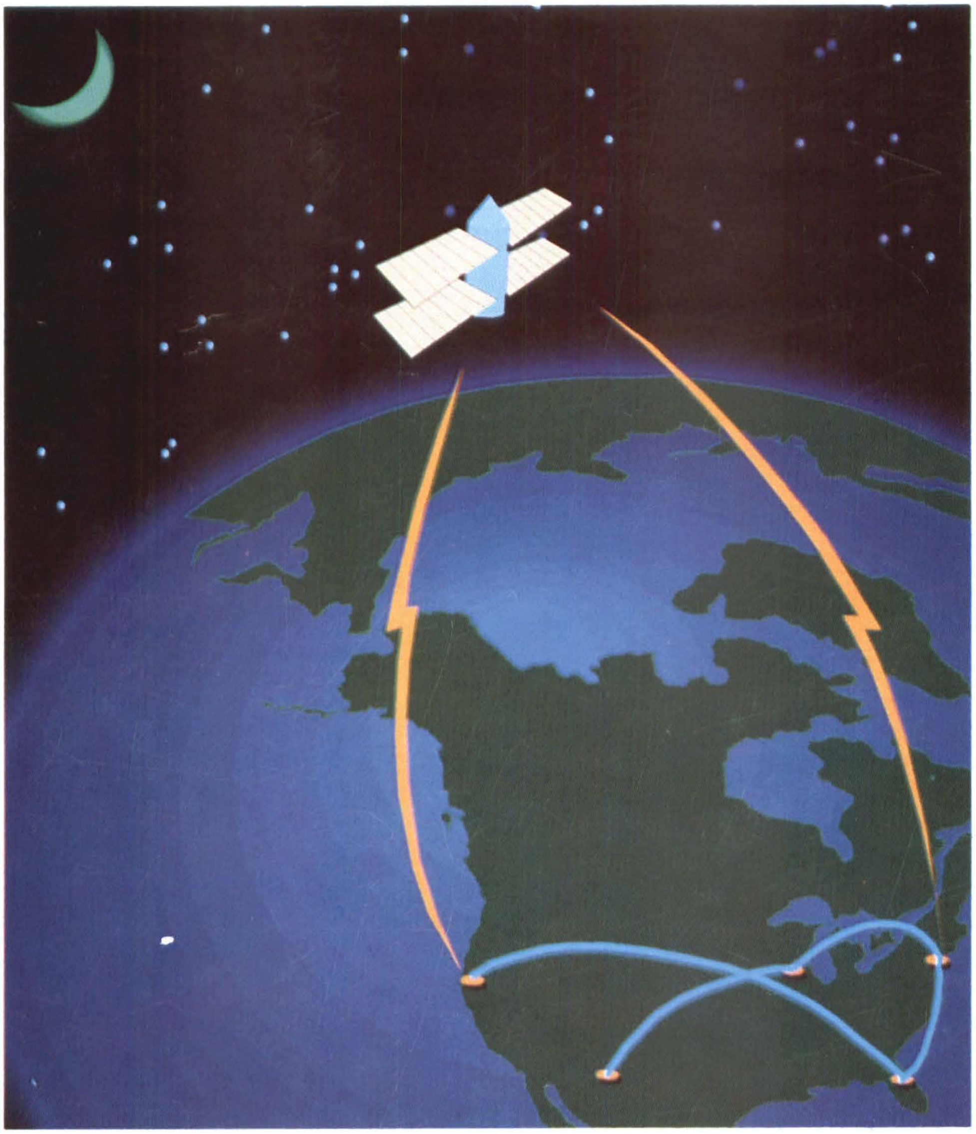

Applied Data Communications Handbook

Universal Data Systems

MOTOROLA INC.
Information Systems Group

APPLIED DATA COMMUNICATIONS HANDBOOK

by

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Manager of Applications Engineering

UNIVERSAL DATA SYSTEMS

Preface

Undertaking a study of Data Communications must be approached in the same manner as building a house. If you are building a house you must first lay a good foundation. Then you build the frame of the house. Finally, you roof the house and put the finishing touches on it. In the study of Data Communications you must first lay a good foundation of basic concepts. Then you must build a frame work of practical knowledge. Finally, you top it off by adding the finishing touches of detailed information. Much the same approach was taken in the seven layers of the International Standards Organization (ISO) Open Systems Interface (OSI) reference model. Each of the seven layers is made up of abstract machines that are based upon the inputs from the previous layer. This study of Data Communications will follow basic ISO/OSI reference model. Since there is very little standardization at this point beyond the third layer, we will concentrate on these first three layers.

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Appendices

List of Figures

I. History of Data Communications

1832 - First telegraph communications using Morse Code

1860 - Pony Express

1930 - Teletype systems using first crude modems

1964 - Rand Corporation published material on store-and-forward concept of transferring messages.

1964 - L. Kleinrock produced a book on queueing aspects communication networks, establishing theoretical basis for design and evaluation of store-and-forward systems.

1965 - D. W. Davies of British National Physical Laboratory credited with coining term "packet."

1966 - U. S. Defense Advanced Research Project Agency (DARPA) demonstrated feasibility of connecting heterogeneous computer to share resources.

1968 - Carterphone court decision permitted "Foreign equipment" (foreign to the Telephone company) to be attached through a Bell provided protective circuitry called a Data Access Arrangement (DAA). The purpose of the DAA was to protect the Telephone Company Central Office (CO) from high voltage, high signal level, and out of band frequencies.

1969 - Arpanet connected four computers together via packet switching system.

1970 - University of Hawaii operated UHF packet broadcast system. (Aloha)

1970 - Approximately 15000 modems installed by Independent modem manufacturers (by other than "Bell").

1972 - Arpanet packet switching demonstration at the first International Conference on Computer Communication. System Capabilities: Text editors, Computer-aided mathematical tool, Multicomputer air traffic-control simulator, Electronic message system and interactive graphic systems.

1973 - Telenet Communications Corporation set up a public packet switching system.

1975 - Xerox Palo Alto Research Center (PARC) anouncement of experimental Ethernet local area network alliance between Digital Equipment Corporation, Intel Corporation, and Xerox Corporation DIX.

1976 - CCITT Recommendation X.25.

1977 - International Organization for Standardization (OSI) Technical Committee.

1978 - Federal Communications Commission (FCC) established Part 68 of the FCC Rules and Regulations. It permitted anyone to submit a DAA for FCC Registration. It also permitted "Direct Connection" of devices to the telephone line. "Direct Connection" permitted modem and DAA to be registered as a single unit (contained in one housing).

1980 - Approximately 250,000 modems installed by independent modem manufacturers.

1982 - IEEE 802 Local Area Network (LAN) Standards Committee established.

1982 - Open Systems Interconnection (OSI) Reference Model

1984 - Started work on Integrated Services Digital Network (ISDN).

1984 - Divestiture of "Bell."

1984 - Approximately 5 million modems installed by independent modem manufacturers.

II. STANDARDS ORGANIZATIONS

1. International Telecommunications Union
   A. Consultative Committee for International Telegraph and Telephone (CCITT)
      - set voluntary International Communications Standard
      - used consistently throughout Europe
      - mixed usage in U. S. due mainly to defacto standards from AT&T and IBM
      - should gain popularity in U. S. in the future
      - V. series deal with physical links and modems
      - X. series deal with networks

   B. International Standards Organization (ISO)
      - define computer and data-processing standard
      - work closely with CCITT
      - voluntary compliance

2. Electronic Industries Association (EIA)
   - run by EIA Trade Association
   - voluntary compliance
   - membership is composed of Electronic Industries

3. Institute of Electrical and Electronics Engineers (IEEE)
   - based on member recommendations

4. American National Standard Institute (ANSI)
   - run by Computer and Business Equipment Manufacturers Association
   - voluntary compliance
   - provide technical representation to CCITT and ISO
   - formulate standards for use by Federal Government (Federal Information Processing Standards - FIPS)

5. National Bureau of Standards (NBS)
   - formulate standard for use by Federal Government (Federal Information Processing Standards - FIPS)
   - provide technical representation to CCITT and ISO

6. National Communications Systems (NCS)
   - developed under Federal Telecommunications Standards Project
   - eventually become FIPS

7. Societe Internationale de Telecommunications Aeronautiques (SITA)
   - International Communications Network standards for Airline reservations systems

III. Types of Networks and their uses

1. Network - data communications systems which allows a number of independent devices to communicate with each other.

   A. Wide Area Network (WAN)
   - interconnect facilities in different parts of the country
   - may be a public utility
   - moderate data rates
   - high error rates (1 in 10^6) and long delays

   B. Metropolitan Area Network (MAN)
   - large geographical area - several blocks of buildings
   - moderate to high data rates
   - moderately high error rates (1 in 10^8) and moderate delays
   - may be owned by a single organization. Used by many individuals and organizations
   - may be a public utility
   - provide means of internetworking of local area networks

   C. Local Area Network (LAN)
   - "a Local Area Network (LAN) is an information transmission facility connecting two or more stations in which the signal propagation delay is less than the time required to transmit a typical information bearing frame, but is long compared to the time required to transfer a single unit of information." (U. S. contribution to ISO/TC97, special ad hoc group on Local Area Network, June 1981)
   - moderately-sized geographical area. Single office building, warehouse or a campus (2<10Km in diameter)
   - high data rate (1 MBPS or greater)
   - lower error rate (1 in 10^9)
   - low delay
   - typically owned by a single organization
   - not normally used in home or heavy industrial environments

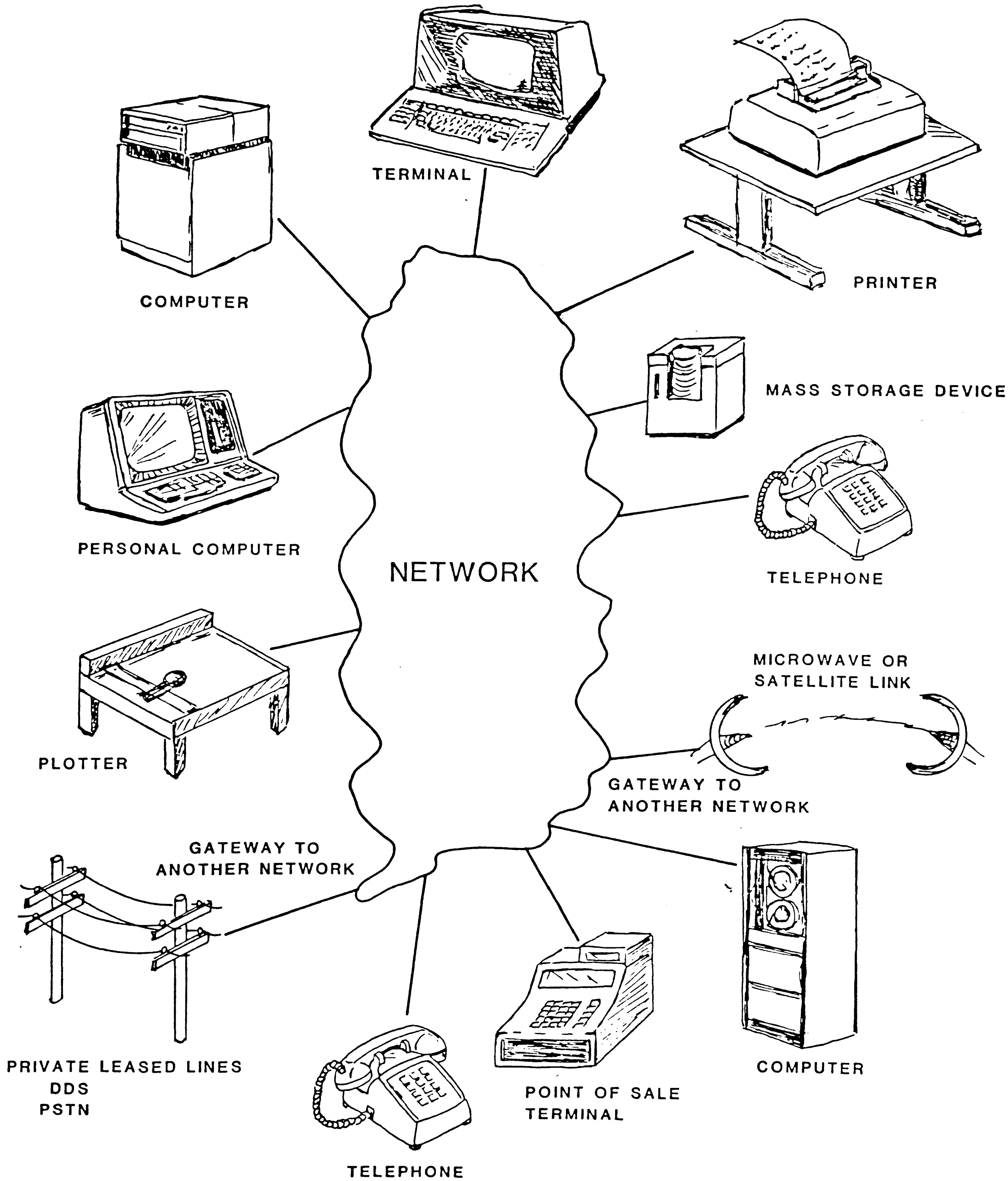
- not normally used for process control and other realtime high reliability applications.

- not normally used to support high security applications.

- not used to interconnect devices on a desk top or component within a single piece of equipment.

2. Typical Applications supported by Networks
   - file transfer and access protocols
   - graphical applications
   - word processing
   - electronic mail
   - remote data base access
   - digital voice and digital video

3. Typical Data Devices supported by Networks
   - computers
   - terminals
   - mass storage devices
   - printers/plotters
   - photo- and telecopiers
   - image monitors
   - monitoring and control equipment
   - gateways to other networks

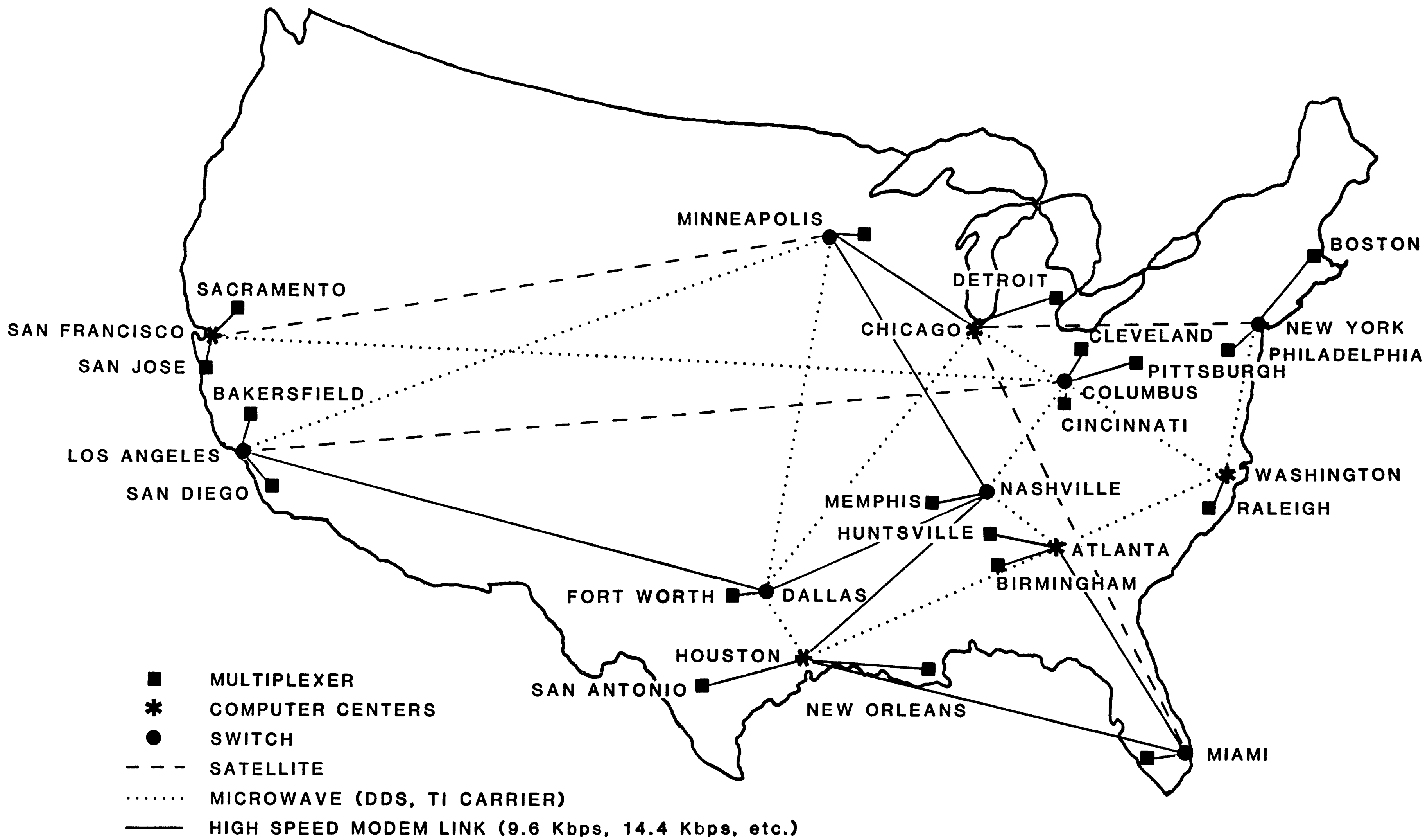


EXAMPLE OF A NETWORK

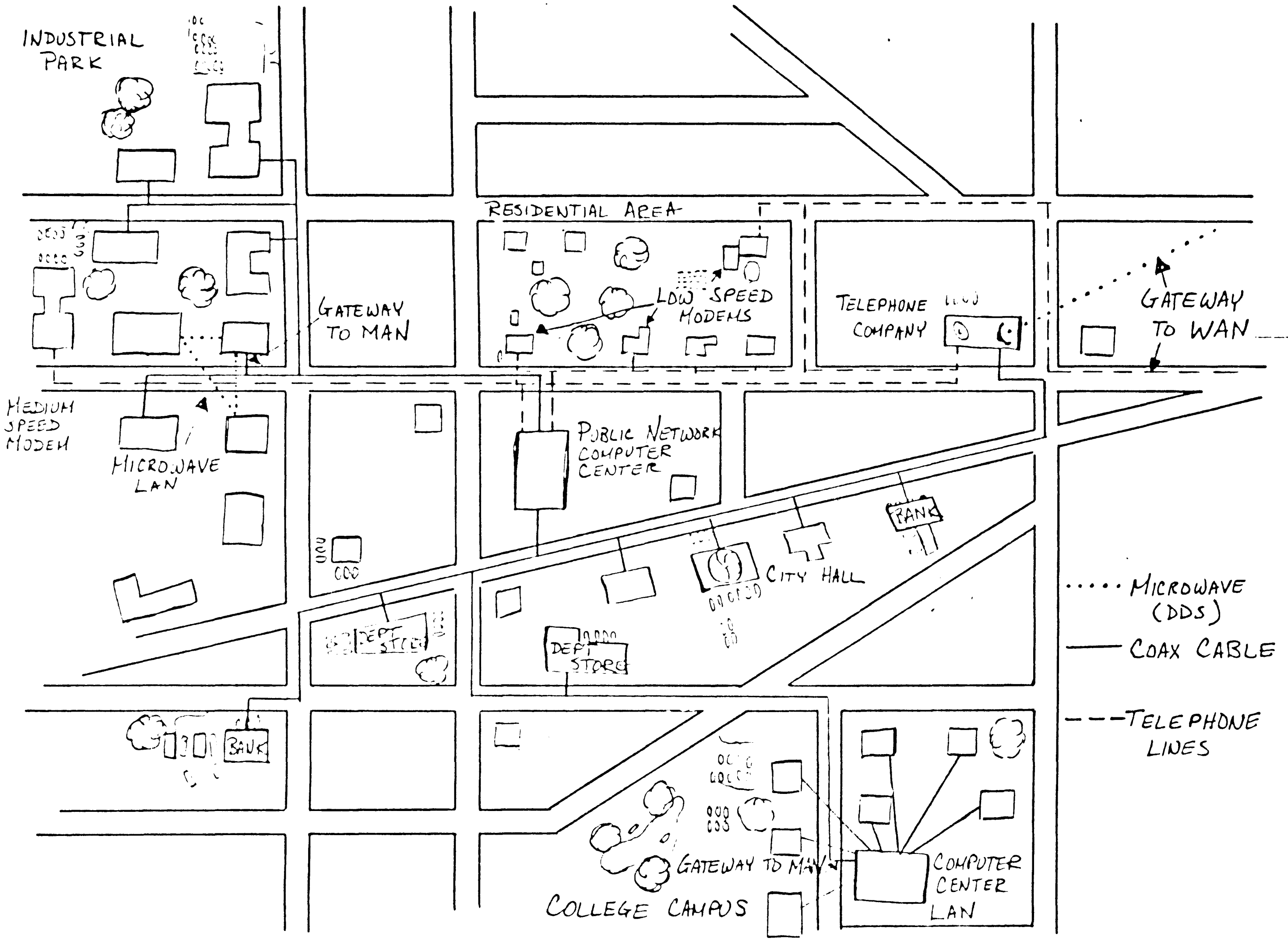
TYPE OF NETWORK	LOCATION OF PROCESSORS	DISTANCE BETWEEN PROCESSORS
Interconnection of WANs - Long Haul	Planet	10,000 km
Wide Area Network (WAN) - Long Haul	Continent	1000 km
	Country	100 km
Metropolitan Area Network (MAN)	City	10 km
Local Area Network (LAN)	Campus	1 km
	Building	100 m
	Room	10 m
Multiprocessor	System	1 m
Machine	Circuit Board	0.1 m

CLASSIFICATIONS OF INTERCONNECTIONS
OF PROCESSORS BY PHYSICAL DISTANCE

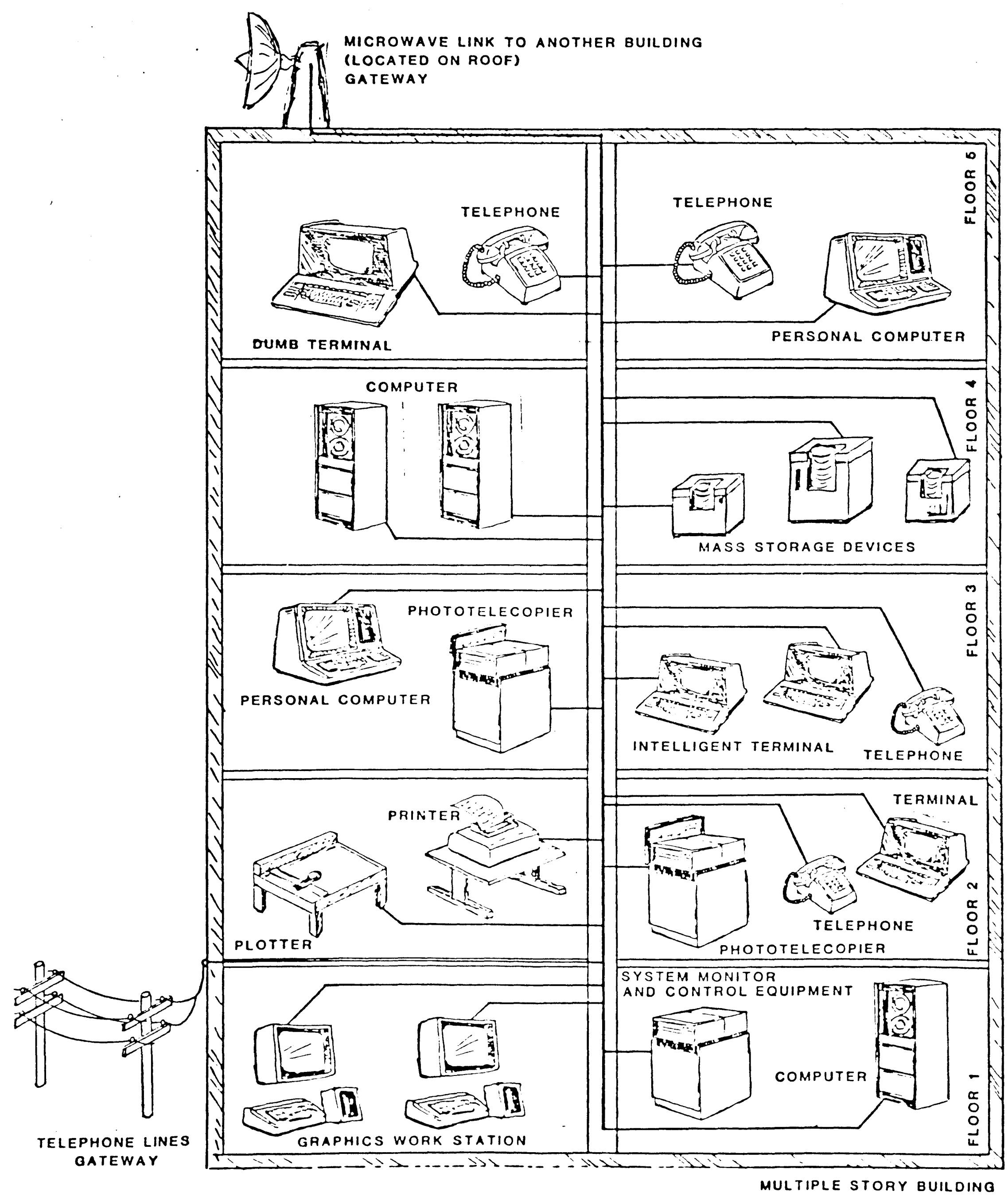
8



EXAMPLE OF WIDE AREA NETWORK (WAN)



EXAMPLE OF A METROPOLITAM AREA NETWORK (MAN)



EXAMPLE OF A LOCAL AREA NETWORK

IV. International Standards Organization (ISO) for reference model of Open Systems Interconnection (OSI)

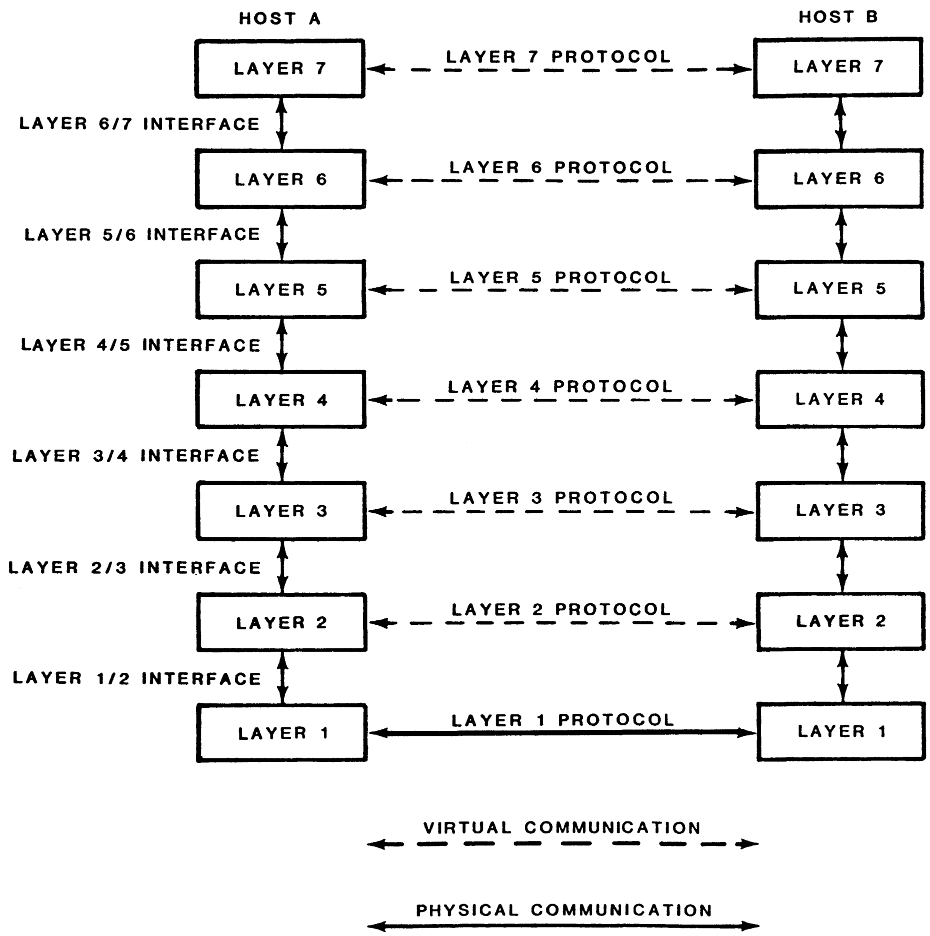
1. This standard defines a common set of rules that define the way participating network nodes must interact in order to communicate and exchange information.

2. Interface
   - relationship between different modules that are usually operating within a network node.
   - typically, a module in one layer will interface with a module in the layer below it to receive a service.

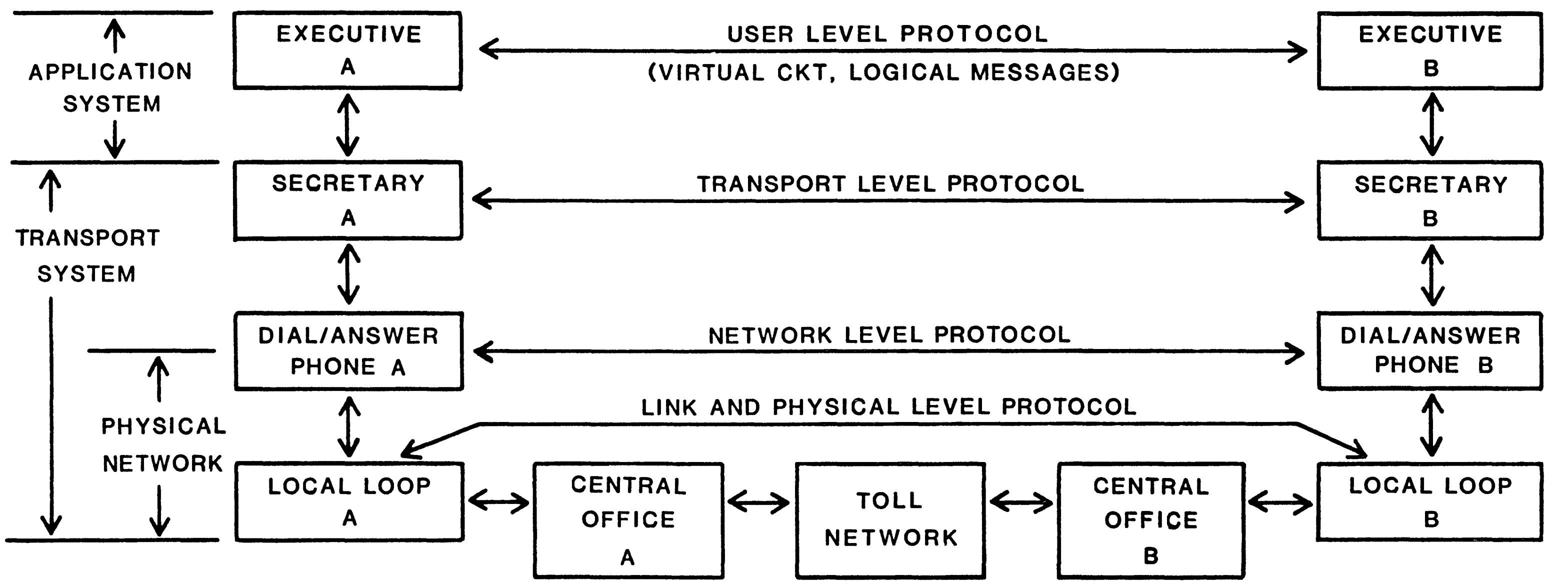
3. Protocols
   - relationships between equivalent modules usually in different nodes.
   - protocols define format and the rules for message exchange.
   - establish standard elements (character, message, file, headers, jobs).
   - establish convention and parameters (timing, code set, formats, speed, control).
   - establish standard communications path (addressing, priority, error control, flow control, routing, path-set up/disconnect).

4. Physical Communication is only provided in the lower layer of the network. The node are physically connected by the way of some media.

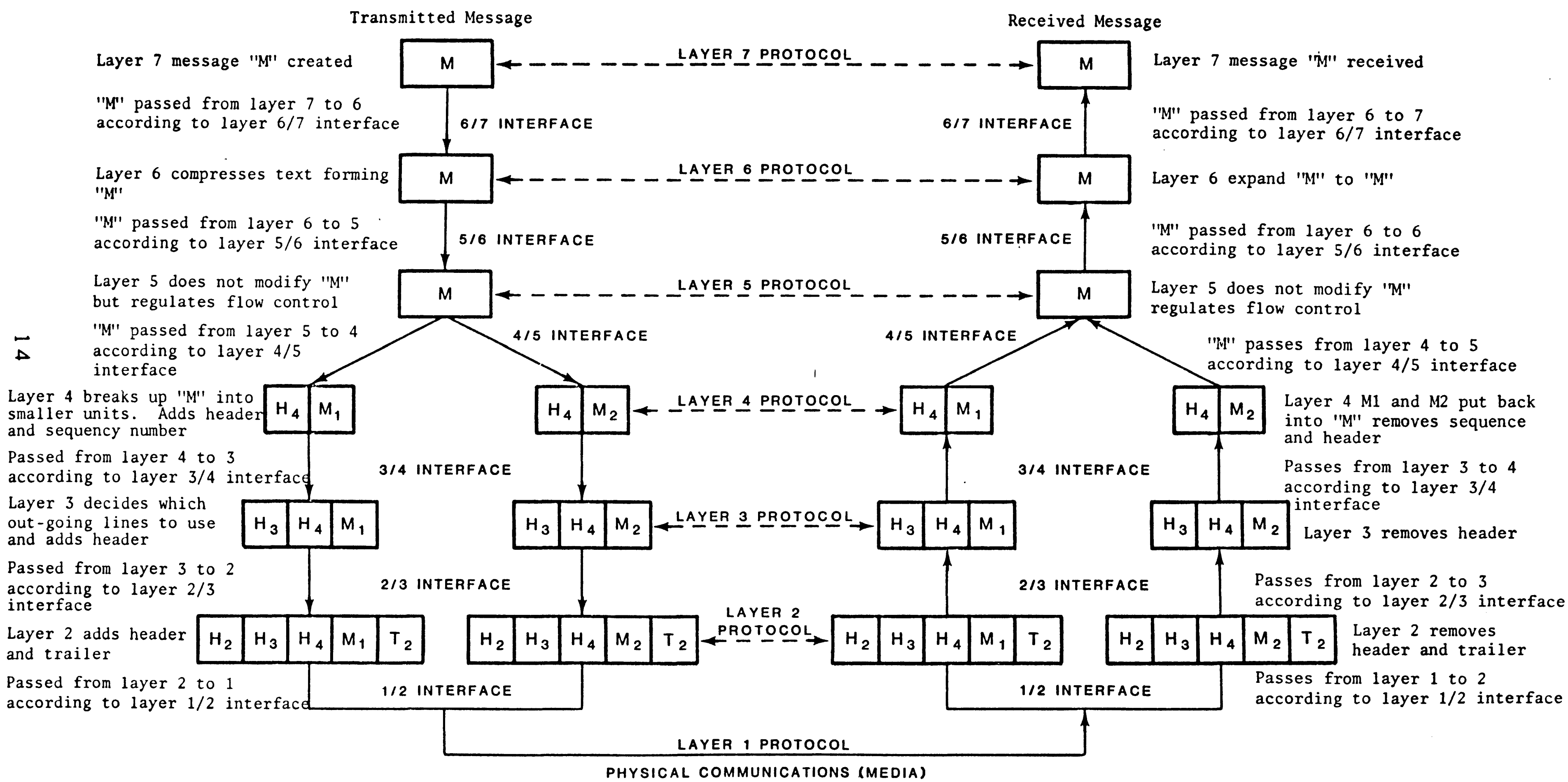
5. Virtual Communication is provided on all higher layers. These layers appear to the user to be physically connected although there is no physical connection.



LAYERS, PROTOCOLS AND INTERFACES



EXAMPLE OF A SIMPLE LAYERED PROTOCOL SYSTEM



VIRTUAL COMMUNICATIONS USING A SEVEN LAYER SYSTEM

6. Seven Levels of OSI Reference Model

A. Physical Link Layer - Level 1
- defines electrical and mechanical aspects of interfacing to a physical medium for transmitting data as well as setting up, maintaining and disconnecting physical links.

- this layer includes the software device driver for each communication device plus the hardware itself (interface device, modem, communication lines).

B. Data Link Layer - Level 2
- establishes an error-free communication path between network nodes over the physical channel, frames messages for transmission, checks integrity of received messages, manages access to and use of the channel, ensures proper sequence of transmitted data.

C. Network Control Layer - Level 3
- address messages, set-up the path between communications nodes, routes messages across intervening nodes to their destination, and controls the flow of messages between nodes.

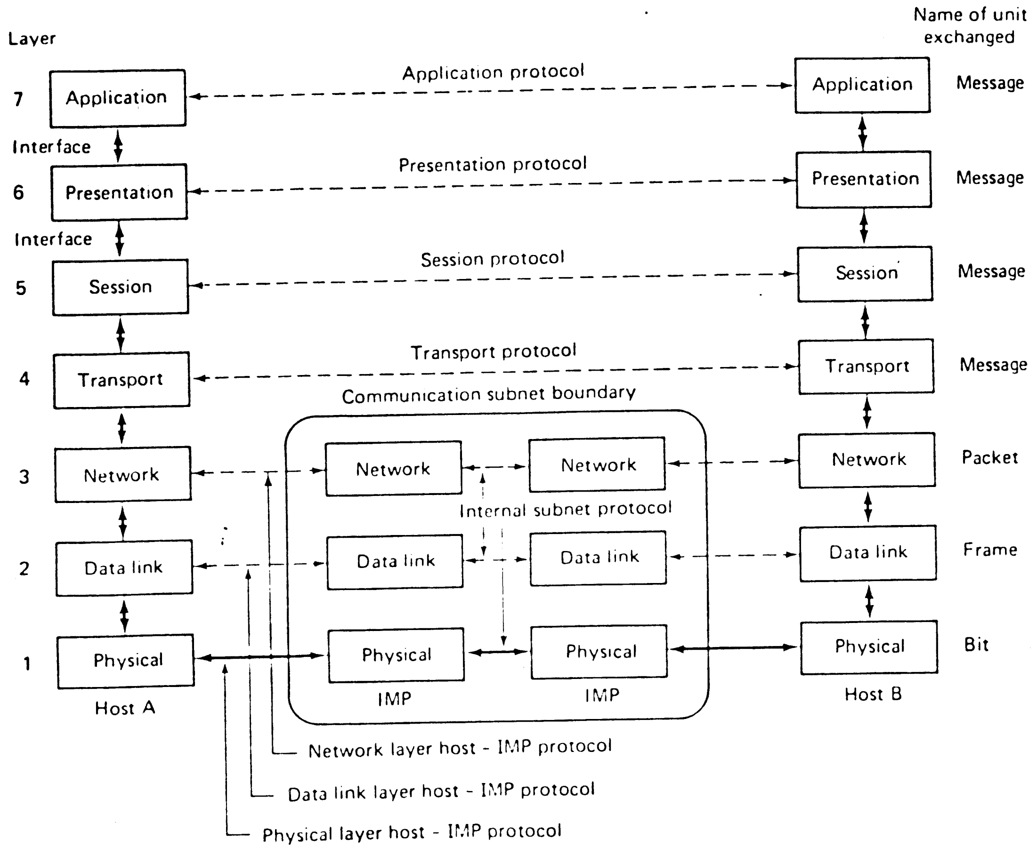
D. Transport Layer - Layer 4
- provides end to end control of a communications session once the path has been established, allowing processes to exchange data reliably and sequentially, independent of which systems are communicating or their location in the network of datagrams and virtual circuits.

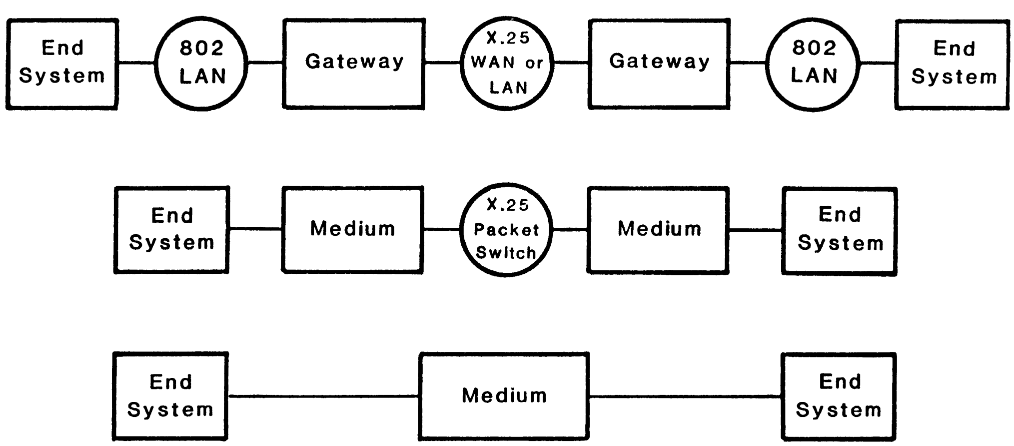
E. Session Control - Layer 5
- establishes and controls system dependent aspects of communications sessions between specific nodes in the network and bridges the gap between the services provided by transport layer and the logical functions running under the operating system in a participating node.

F. Presentation Control - Layer 6
- encoded data that has been transmitted is translated and converted into formats which enable display on terminal screens and printers forms that can be understood and directly manipulated by uses.

G. Application/User Lay - Layer 7

- services are provided that directly support user and application tasks and overall system management. Examples of services and applications provided at this level are resouce sharing file transfers, remote file access data base management, and network management.





ISO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTIONS

Layer	ISO/OSI	DOD ARPANET	IBM SNA	DEC DECNET	Xerox	CCITT Standards
7	Application	User	End user	Application		
6	Presentation	Telnet, FTP	NAU services		Remote Procedure Call	X.3 X.28 X.29
5	Session	(None)	Data flow control	(None)	Sequenced Packet	
			Transmission control			
4	Transport	Host-host		Network services		Transport Service
		Source to destination IMP	Path control			
3	Network			Transport	Internet Datagram	X.25 Packet Level
2	Data link	IMP-IMP	Data link control SDLC	Data link control DDCMP	Ethernet	HDLC
1	Physical	Physical	Physical	Physical		X.21 Bis V.24/28

APPROXIMATE CORRESPONDENCE BETWEEN THE VARIOUS NETWORKS

ARPANET - Advanced Research Projects Agency Network
DDCMP - Digital Data Communications Message Protocol
DEC - Digital Equipment Corporation
DECNET - Digital Equipment Corporation Network
DNA - Digital Network Architecture
DOD - Department of Defence
FTP- File Transfer Protocol
HDLC - High Level Data Link Control
IBM - International Business Machine
IMP - Interface Message Processors (communication computer packet switch, node, data switching exchange
ISO - International Standards Organization
NAU - Network Addressable Unit
OSI - Open Systems Interconnection
SNA - Systems Network Architecture
X.3 - Packet assembly/dissembly facility (PAD)in a public network
X.21 - General purpose interface between DTE and DCE for synchronous operation on public data network
V.24 - List of definitions for interchange circuits between data terminal equipment and data circuit terminating equipment
X.25 - Interface between DTE and DCE for terminal operating in the packet mode on public data networks
V.28 - DTE/DCE interface for a start/stop mode data terminal equipment PAD on a public data network situated in the same county

7. Institute of Electrical and Electronic Engineering (IEEE) Standard 802 on Local Area Networks (LAN) and Metropolitan Area Networks (MAN)

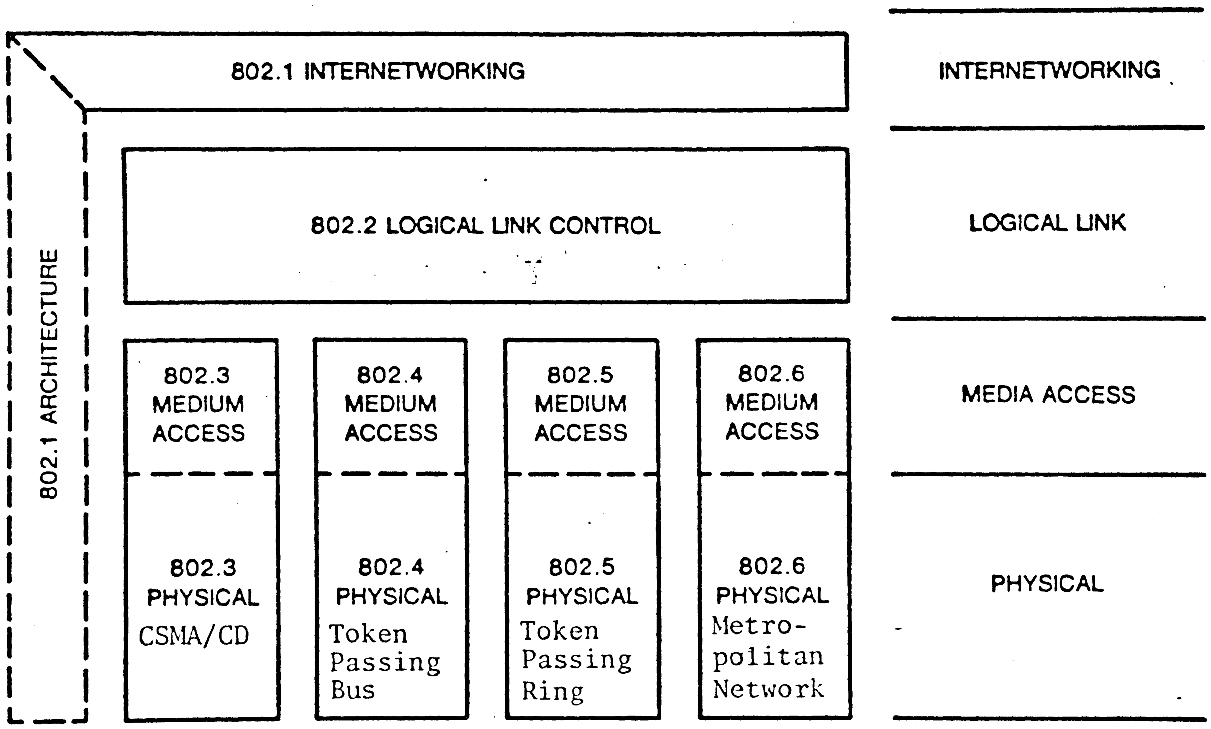
(A) This family of standard defines a set of interface and protocols for local and metropolitan area networks

- Local Area Network (LAN) is a type of data communications network that is usually contained to a moderately sized geographical area.

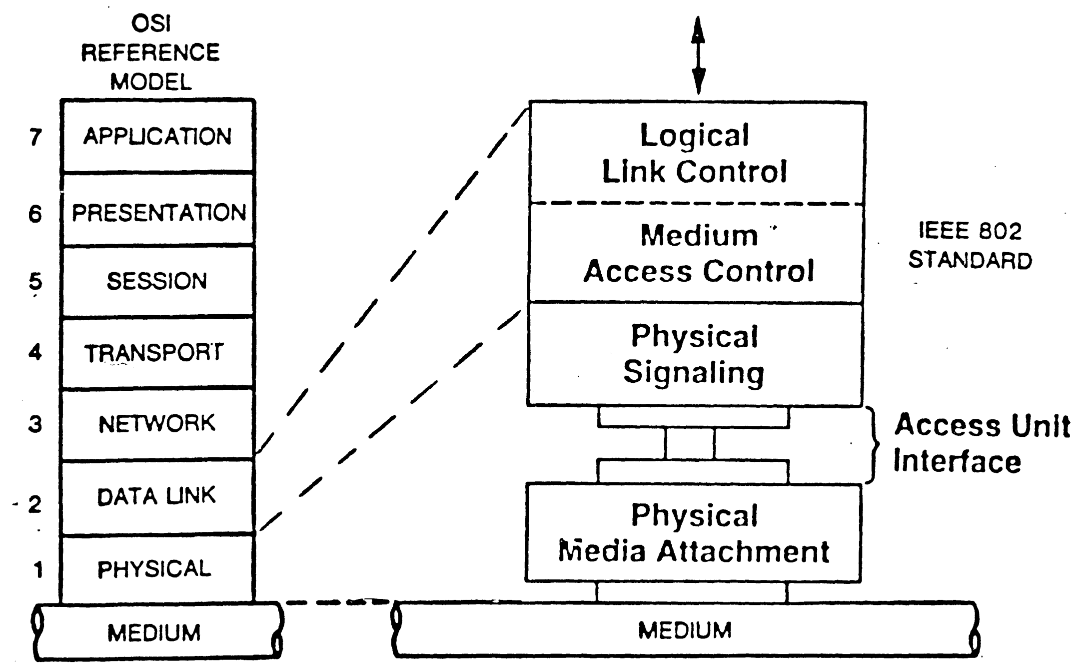
- Metropolitan Area Network (MAN) is a type of data communication network that is usually in large geographical areas such as several blocks.

(B) Six Standards Embodied in IEEE 802

- IEEE Standard 802.1 = Architecture and Internetworking
- IEEE Standard 802.2 = Logical Link Control
- IEEE Standard 802.3 = CSMA/CD Access Method and Physical Layer Specifications
- IEEE Standard 802.4 = Token-Passing Bus Access Method and Physical Layer Specifications
- IEEE Standard 802.5 = Token-Passing Ring Access Method and Physical Layer Specifications
- IEEE Standard 802.6 = Metropolitan Network Access Method and Physical Layer Specifications



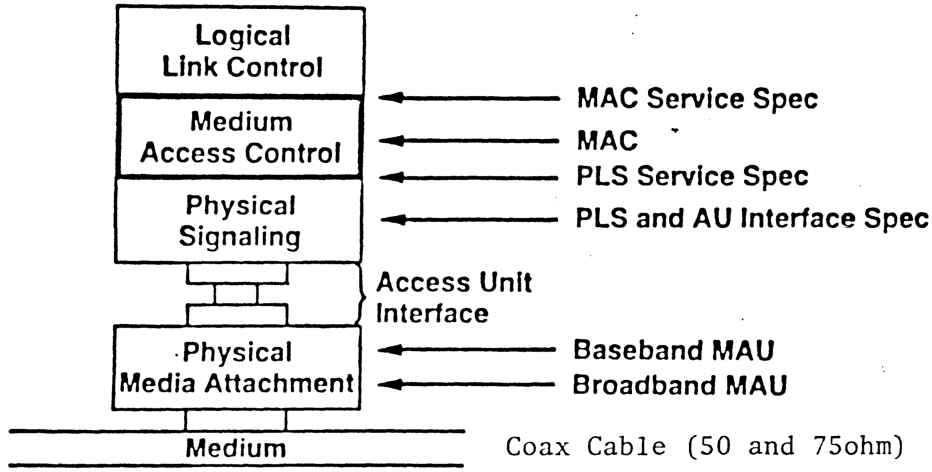
RELATIONSHIP OF IEEE 802 STANDARDS



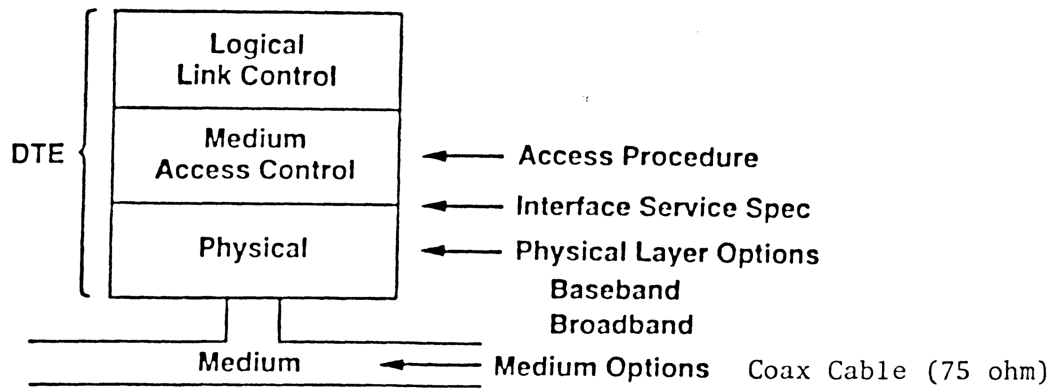
RELATIONSHIP OF OSI REFERENCE MODEL
TO IEEE 802

IEEE STD	802.3		802.4			802.5	
Access Control	CSMA/CD		Token Bus			Token Ring	
Medium	Baseband Coax 50 Ω	Broadband Coax 75 Ω	Baseband Coax 75 Ω		Broadband Coax 75 Ω	Baseband Twisted Pair 150 Ω	Baseband Coax 75 Ω
Type Signaling	Manchester	VSB	Phase Continuous FSK	Phase Coherent FSK	Multi-Level Duobinary AM/PSK	Differential Manchester	Differential Manchester
Data Rate	10 Mb/s	10 (1, 5 TBD)	1 Mbps	5, 10 Mbps	1,5,10,20 Mbps	1,4 Mbps	4,20,40 Mbps

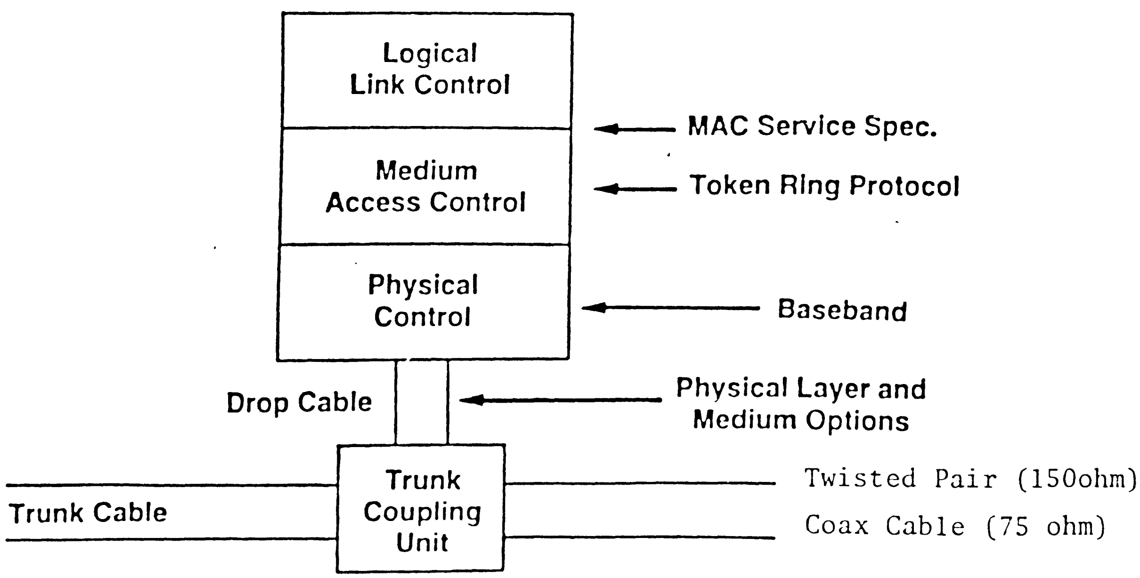
IEEE 802 OPTION TABLE



CSMA/CD (802.3)



Token Bus (802.4)



Token Ring (802.5)

IEEE 802 Options

V. Physical Layer

1. DATA BASICS

Data - digital information (normally binary) that is sent from one location to another location. Information expressed in a formalized way (usually in digital form) for processing, storage or transmimssion.

Bit - the smallest piece of information contained in a data transmission - Binary 1 or 0.

Byte - a small group of data bits which are handled as a unit - character or word.

Frame - a block of data in data link control procedure

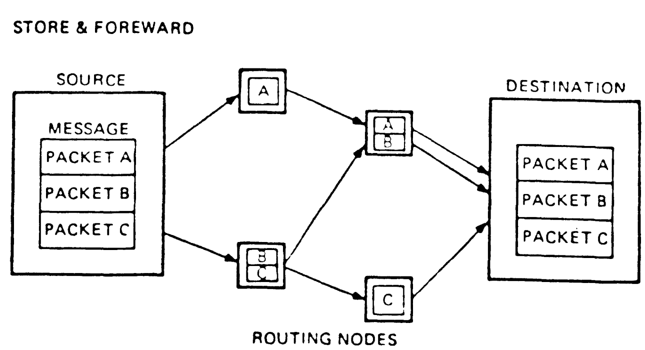
Packet - a block of data handled by a network in a well-defined format including a header and having a maximum size of data field. Consequently, a message may have to be carried as several packets.

Datagram - a packet which is transported by a network independently of other packets. A datagram service handles packets separately and compared with a virtual call service which a call must be first established.

Virtual Circuit - a facility in a packet-switched communications network in which packets passing between a pair of terminals are kept in sequence.

Packet Switching - the transfer of data by means of addressed packets whereby interim point to point channels are available only during the transmission of one packet.

Store and Forward - the handling of messages or packets in a network by accepting them completely into storage before sending them forward to the next switch.



PACKET SWITCHING WITH STORE AND FORWARD HANDLING OF MESSAGES

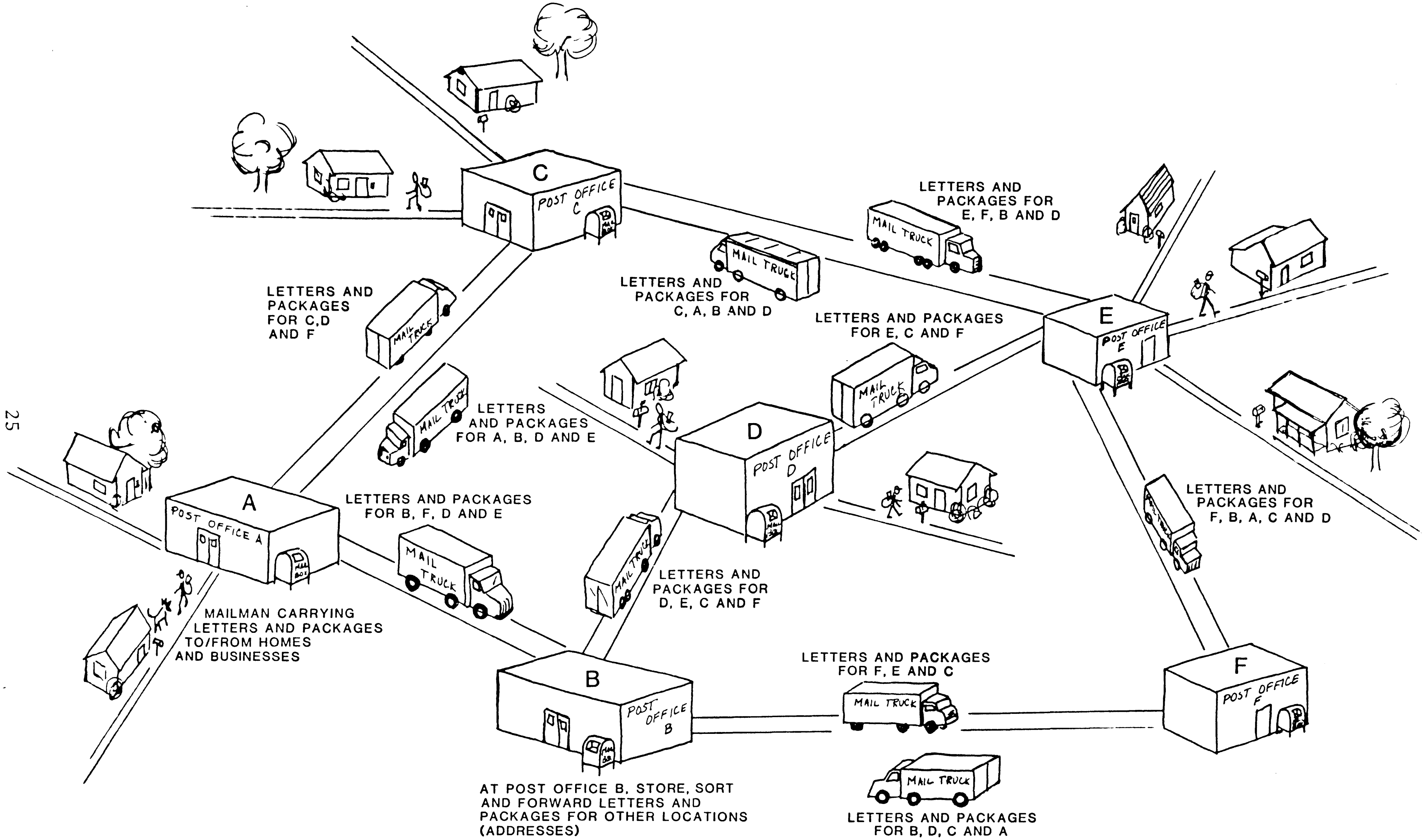
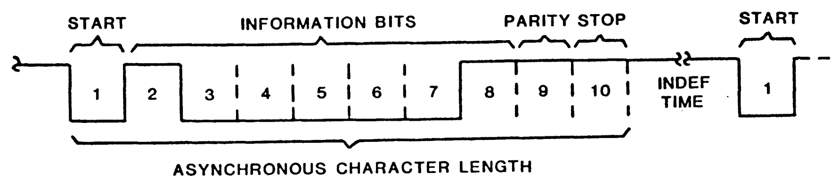


ILLUSTRATION OF STORE AND FORWARD PACKET SWITCHING OF MESSAGES USING MAIL TRUCKS

Asynchronous Data Transmission is data transfer that does not require clocking of the digital signal. Data synchronization in the terminal equipment is achieved by using start and stop bits to frame the data information.



ASYNCHRONOUS CHARACTER (BYTE) AS SEEN ON OSCILLOSCOPE

ASCII character "A" - American Standard code for information interchange

Odd Parity - Number of 1's equals an even number so the 9th bit is made a "1" to make the number of 1's odd.

Parity - is the property of being odd or even. The parity count of a binary sequence is the parity of the number of ones it contains. Parity is a means of checking for errors.

Character Framing - characters framed by a start and stop bit.

Character Size - 10 bits = 1 (start) +7 (information) +1 (parity) +1 (or more stop).

ASYNCHRONOUS DATA TRANSMISSION

Characters are transmitted one at a time with an indefinite time between characters. The time is dependent on the time between key strokes on a terminal.

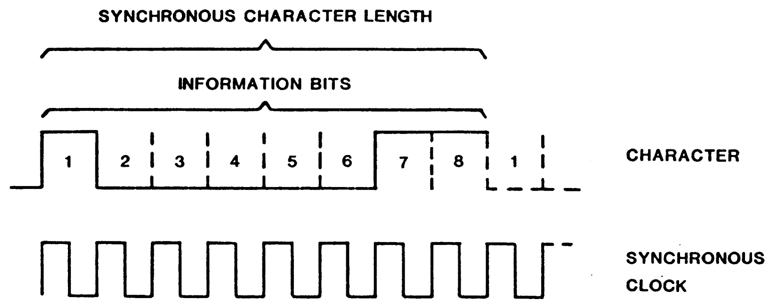
Bit Number									
b_7 →		0	0	0	0	1	1	1	1
b_6 →		0	0	1	1	0	0	1	1
b_5 →		0	!	0	1	0	1	0	1
$b_7\,b_6\,b_5\,b_4\,b_3\,b_2\,b_1$	Row \ Column	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	Ø	•	P	@	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SS	•	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	|
1 1 0 0	12	FF	FS	,	<	L	~	l	¬
1 1 0 1	13	CR	GS	–	=	M	]	m	|
1 1 1 0	14	SO	RS	.	>	N	^	n	|
1 1 1 1	15	SI	US	/	?	0	–	o	DEL

American Standard Code for Information Interchange (ASCII)

NUL (null)	All zeros character, used for fill.
SYN (synchronous idle)	Used in synchronous transmission for character synchronization.
SOH (start of header)	Used at the beginning to indicate routing information.
STX (start of text)	Used at the beginning of a sequence of characters which are to be referred to as text.
ETX (end of text)	Used at the end of text.
ETB (end of block)	Indicates end of a block of data.
EOT (end of transmission)	Used at end of transmission or end of call.
ACK,NAK	Sent by receiving station to the transmitting station to indicate successful (ACK) or unsuccessful (NAK) reception of a message.
DLE (data link escape)	Changes the meaning of a limited number of contiguously following characters.
ENQ (enquiry)	Used as a request for a response from a remote station; typical response may be address or status content of station's buffer.
CAN (cancel)	Disregard the accompanied data.

ASCII Control Codes

Synchronous Data Transmission is data transfer that requires clocking of the digital signal. The clock is used for bit sampling.



SYNCHRONOUS CHARACTER AS SEEN ON OSCILLOSCOPE

EBCDIC Character "A" - Extended Binary Coded Decimal Interchange Code (binary 11000001)
Synchronous Clock - used by terminal equipment for sampling of bits
No Parity - errors are found using a cyclic redundancy check (CRC). This information is contained in the BCC.
Character Size - 8 Bits

SYNCHRONOUS DATA TRANSMISSION

Characters are sent one right after the other. Each bit is synchronized with a clock to permit proper sampling of the data by the terminal equipment and communication equipment.

Sync - a synchronization character used to keep the sending and receiving terminals in step. Sync is added by the sending terminal equipment and removed by receiving terminal equipment.
STX (Start of Text) - identifies the start of the user's information.
Block of Characters - character from a standard code set such as EBCDIC. This is the users information that is being transmitted.
ETX (End of Text) - identifies the end of the user's information.
BCC (Block Check Character) - used for detection of errors which have occurred during the transmission of the user's data.

<table>
<tr><td>HIGH</td><td>LOW B.B.B.B.</td><td>0000</td><td>0001</td><td>0010</td><td>0011</td><td>0100</td><td>0101</td><td>0110</td><td>0111</td><td>1000</td><td>1001</td><td>1010</td><td>1011</td><td>1100</td><td>1101</td><td>1110</td><td>1111</td></tr>
<tr><td>B. B. B. B.</td><td></td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr>
<tr><td>0000</td><td>0</td><td>NUL</td><td>SOH</td><td>STX</td><td>ETX</td><td>PF</td><td>HT</td><td>LC</td><td>DEL</td><td></td><td>RLF</td><td>SMM</td><td>VT</td><td>FF</td><td>CR</td><td>SC</td><td>SI</td></tr>
<tr><td>0001</td><td>1</td><td>DLE</td><td>DC1</td><td>DC2</td><td>DC3</td><td>RES</td><td>NL</td><td>BS</td><td>IL</td><td>CAN</td><td>EM</td><td>CC</td><td></td><td>ITS</td><td>IGS</td><td>IRS</td><td>IUS</td></tr>
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ETB</td><td>ESC/
PRE</td><td></td><td></td><td>3M</td><td></td><td></td><td>ENR</td><td>ACK</td><td>BEL</td></tr>
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<tr><td>1010</td><td>A</td><td></td><td>~</td><td>s</td><td>t</td><td>u</td><td>v</td><td>w</td><td>x</td><td>y</td><td>z</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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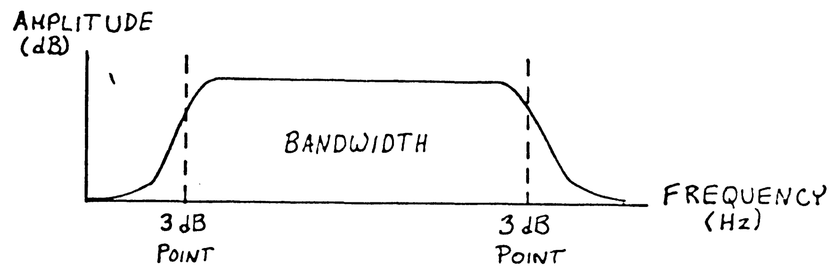
</table>

BINARY — HEX — EBCDIC

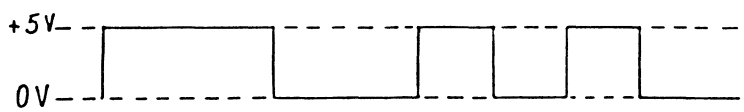
EXTENDED BINARY CODED DECIMAL
INTERCHANGE CODE (EBCDIC)

B. Signaling Basics

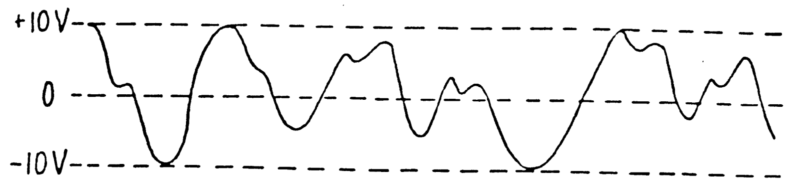
Bandwidth - is the information-carrying capability if a communication line or channel. This bandwidth is different for each type of transmission medium.



Digital Signal - signal can only assume discrete values. For example, the voltage of a digital signal may be constrained to take on only two values such as 0 volts and 5 volts.



Analog Signal - signal may vary continuously over a specified range of values. For example, the voltage of an analog signal may assume any value in the range -10 volts to +10 volts.



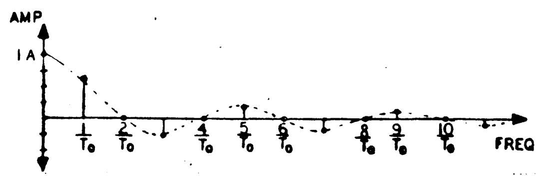
- Spectrum - frequencies at which a signal contains energy.
- Fourier Series for periodic analog signal S(T)

$$S(t) = A_0 + \sum_{n=1}^{\infty}\left[B_n \sin\left(\frac{2\pi}{T_0}nt\right) + A_n \cos\left(\frac{2\pi}{T_0}nt\right)\right]$$

- The Fourier Series for a 50% duty cycle square wave where:

$$S(t) = \frac{1}{2}A + \sum_{m=0}^{\infty} \frac{2A}{(2m+1)\pi}(-1)^m \cos\left(\frac{2\pi}{T_0}(2m+1)t\right)$$

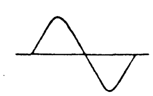
- Amplitude line spectrum of 50% duty cycle square wave S(T).



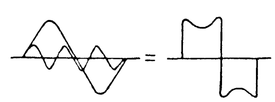
Contains an infinite number of odd harmonics

- A square wave is composed of an infinite number of odd harmonics of the fundamental sine wave.

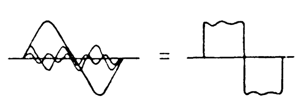
COMPOSITION OF A SQUARE WAVE



Fundamental Sin Wave



Add Odd Harmonic

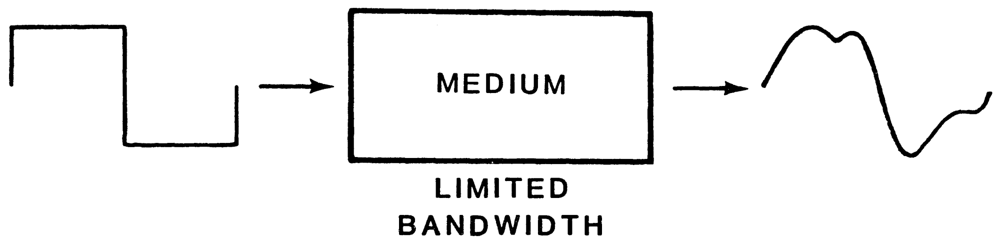


Add More Odd Harmonics

- The low frequency spectral lines affect the slowly changing average value of the signal. The high frequency terms affect rise time and fast changes of the signal.

- Any wave shape can be formed by adding the proper frequencies, amplitudes and phases of sine waves together.

- Because of impairments and the bandwidth of some mediums is limited, some sine waves may change in amplitude and phase as they pass through the medium. Some of the sine waves may be totally removed. Thus, when the signal reaches the other end of the medium, the signal will be distorted. This distortion will cause the wave shape and the information contained in it to be changed.



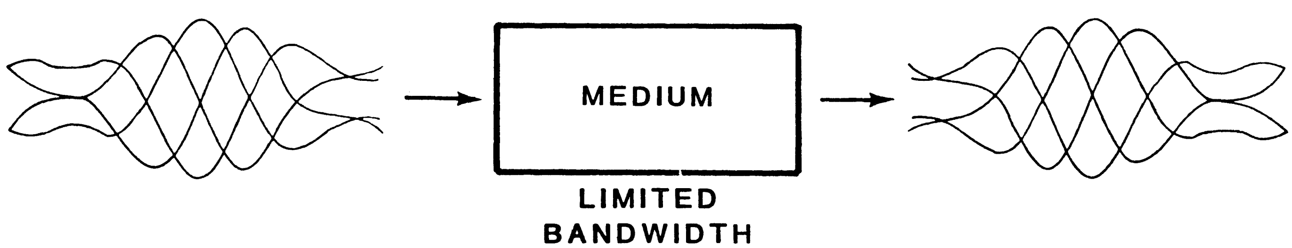
Distortion of Square Wave as it Passes Through a Limited Bandwidth Medium

- If the bandwidth of the medium is limited, a digital signal from the terminal will be sent through a modem.

- <u>Modem</u> - acronym for the words <u>mo</u>dulator and <u>de</u>modulator.

- The modem will condition the digital data so that the transmitted signal "fits" into the bandwidth of the communications medium.

- The modem is a sophisticated digital to analog (D/A) and analog to digital (A/D) converter. It changes the digital data into tones and the tones back into digital data. The tones are designed to transmit efficiently through the bandwidth of the medium.



Very Little Distortion on a Modem Signal as it Passes Through a Limited Bandwidth Medium

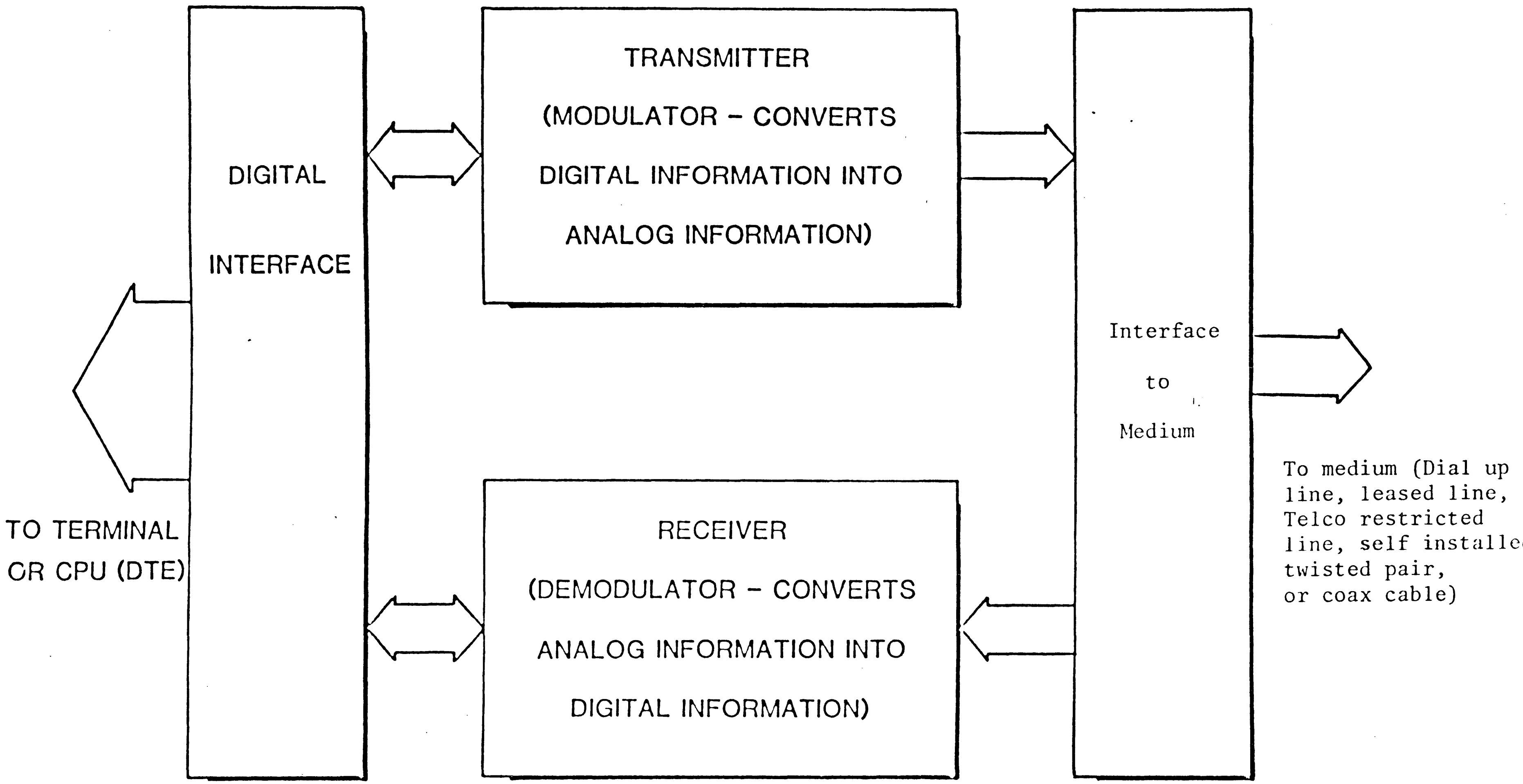
Basic Components of a Modem (DCE)

Digital Interface - Circuitry that interfaces the data Circuit-Terminating equipment (DCE - communications equipment) to the Data Terminal Equipment (DTE).

Transmitter - Converts digital data originating from DTE or other sources into a signal suitable for transmission over the communications medium.

Receiver - Accepts signals from the communications facility, converts the signal back to their original digital format, and presents this digital signal to the appropriate DTE or data sink.

Interface to Medium - Circuitry that interfaces the DCE (communications equipment) to the medium.



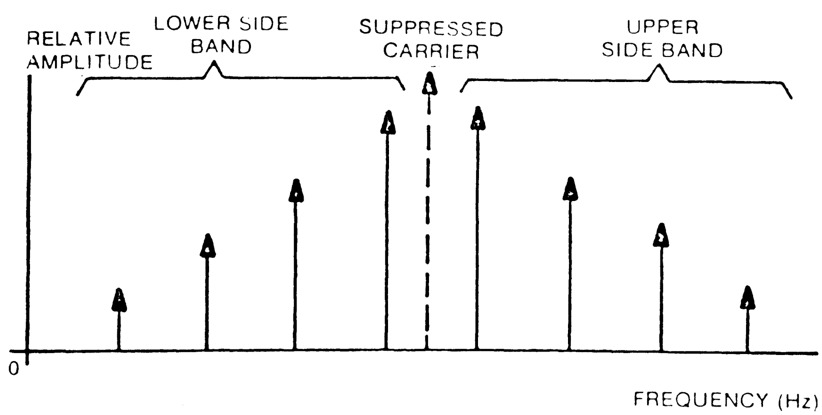
BASIC COMPONENTS OF A MODEM

- Modulation - process of modifying a single frequency (carrier) so that it can carry information.

- Demodulation - process of converting a modulated signal so that the information is recovered.

- Side Bands - sum and difference of carrier and modulation frequency.

- Baseband - the frequency band that information bearing signals occupy before they combine with a carrier in the modulation process.



EXAMPLE OF SPECTRAL CONTENT FOR A MODEM

- The higher the modulation frequency (higher bit rate) the farther away the side bands.

- Higher bit rates require a greater bandwidth.

- Baud - The unit of signaling. It is the number of signal elements per second. Since a signal element can represent more than one bit, baud rate is not the same as bits per second. Baud rate is the bit rate divided by bits per symbol.

- Multilevel Encoding - combining of 1, 2, 3, or 4 bits into a symbol to reduce the bandwidth of the transmitted signal. These symbols may be represented by different phase angles in a phase shift keyed modulation technique.

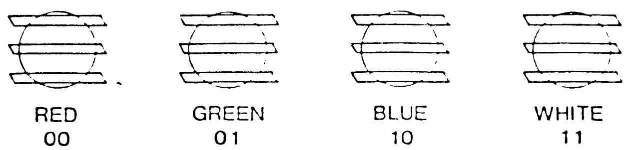
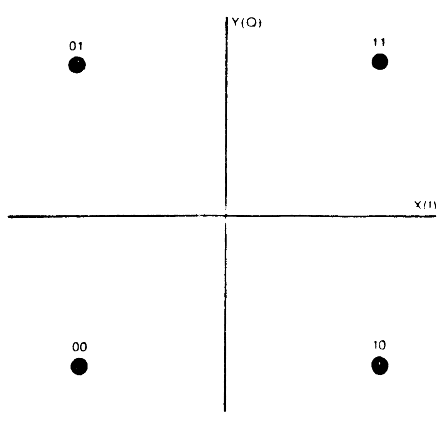


Illustration of Multi-Level Encoding of Data

Combinations of bits are represented by different color of light (symbols). Twice as much information is contained in each unit information transmitted. Twice as much information can be transferred in a given amount of time.

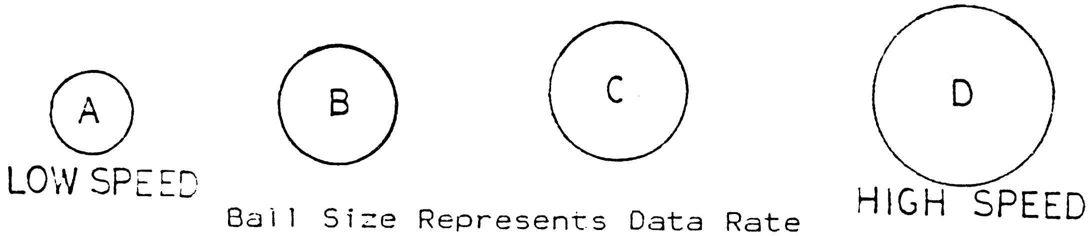


AS SEEN ON O'SCOPE (X AND Y INPUT)

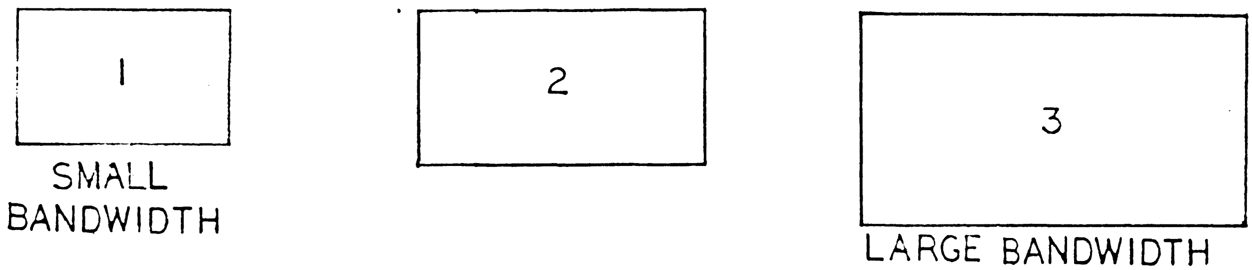
Illustration of Multi-Level Encoding of Data in the Constellation of a Phase Shift Keyed (PSK) Modem

Combinations of bits are represented by different phase angles in the constellation of a PSK modem. The required bandwidth for a given bit rate is reduced by sending twice as much information in each unit of information.

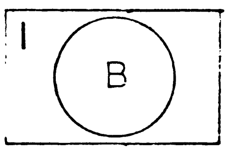
Illustration of Data Rate Versus Required Bandwidth using Balls and Boxes



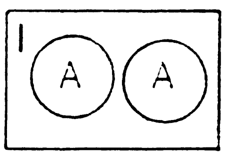
Ball Size Represents Data Rate



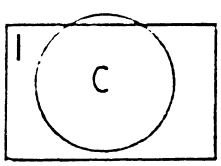
Box Size Represents Bandwidth of Medium



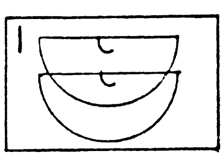
Data rate "B" will fit into Box 1



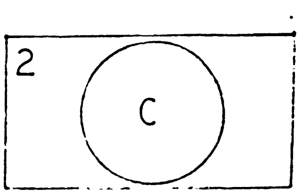
More than one lower speed channel of data rate "A" will fit into Box "1". This is called frequency division multiplexing (FDM).



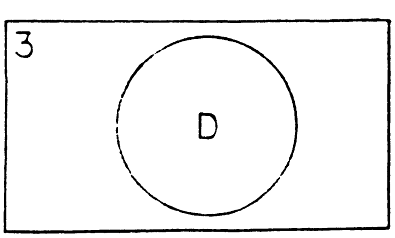
Data rate "C" will not fit into Box "1" unless the baud rate is decreased by using multi-level encoding.



Data rate "C" will fit into Box "1" if the baud rate is decreased by using multi-level encoding.



Data rate "C" will fit into the larger bandwidth of box "2" without multi-level encoding.



Very high data rates will fit into very large bandwidths without sophisticated modulation techniques or multi-level encoding.

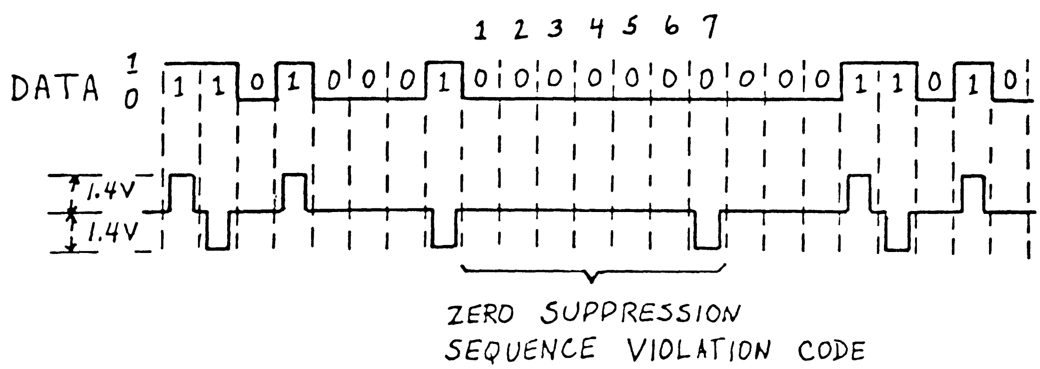
3. Types of Signaling and modulation

- BaseBand - Signaling techniques that can be classified as non-carrier type.

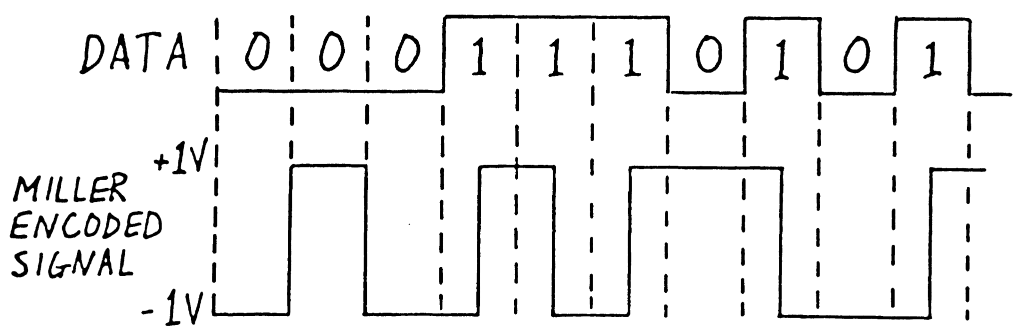
- Carrier Modulation - Signaling techniques that involve modulation of a sinusoidal carrier signal.

- BroadBand - is a term that describes a type of wide bandwidth communications that uses coaxial cable as its distribution medium and frequency division multi-plexing (FDM) as its channel allocation scheme. Uses carrier modulation signaling techniques.

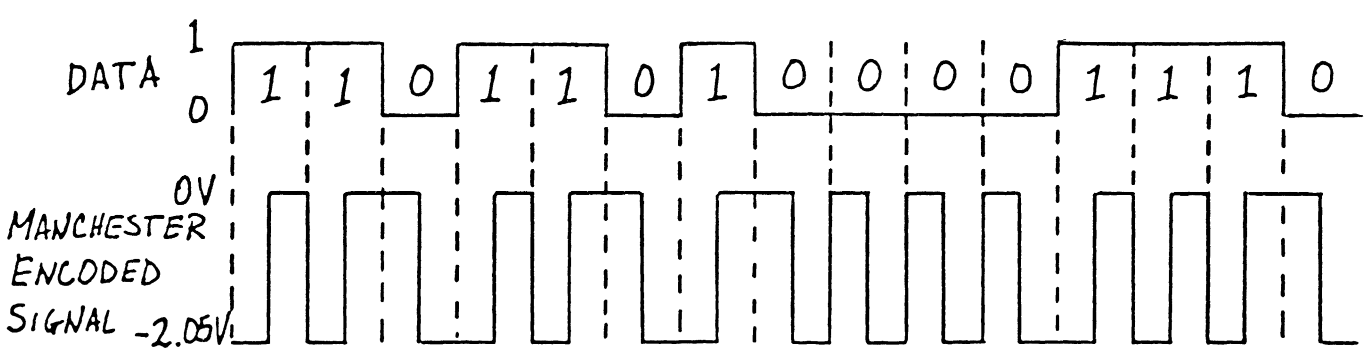
BiPolar Return to Zero (RZ) Signaling with Violation Code for Zero Suppression Sequence - A signaling technique used for Baseband Transmission. This encoding scheme uses three level signaling whereby a "zero" is represented by a zero signal level and successive "ones" are represented by equal-magnitude opposite-polarity pulses that are one-half a bit period wide. If seven or more "zeros" are sent in a row, the seventh zero is represented by a pulse in the same direction (violation code).



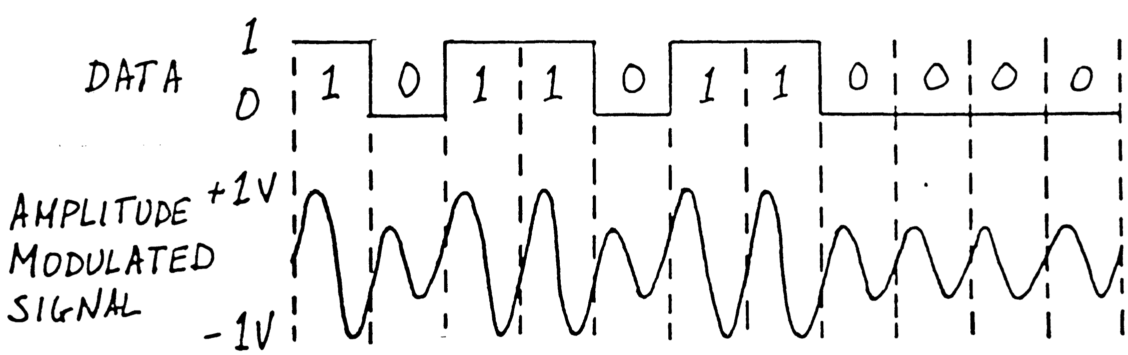
• Miller Encoding (Delay Modulation) - an encoding scheme used for baseband transmission. In this encoding scheme, a binary "one " is represented by a signal transition at the midpoint of the bit interval. No transition represents a "zero" unless it is followed by another zero. In this instance, a transition is placed at the end of the bit period of the first zero.



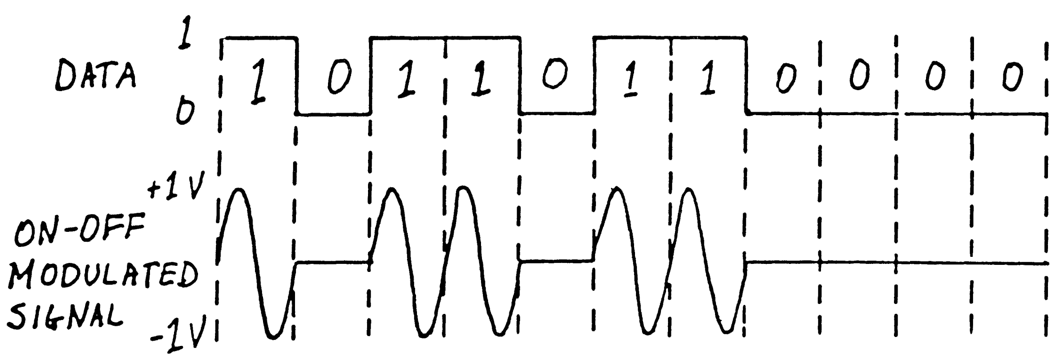
<u>Manchester</u> <u>Encoding</u> - an encoding scheme used for baseband transmission. The signal has a 50% duty cycle and insures a transition in the middle of every bit cell (data transition). The first half of the bit cell contains the complement of the bit valve and the second half contains the true value of the bit.



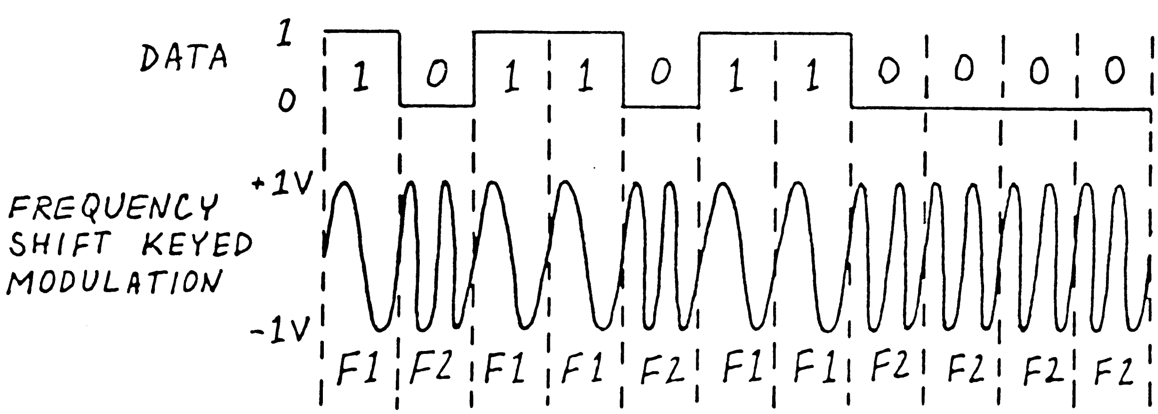
- Amplitude Modulation (AM) - transmission of information on a communication line by varying the voltage level (amplitude). A "one" is represented by a higher signal level. A "zero" is represented by a lower signal level.



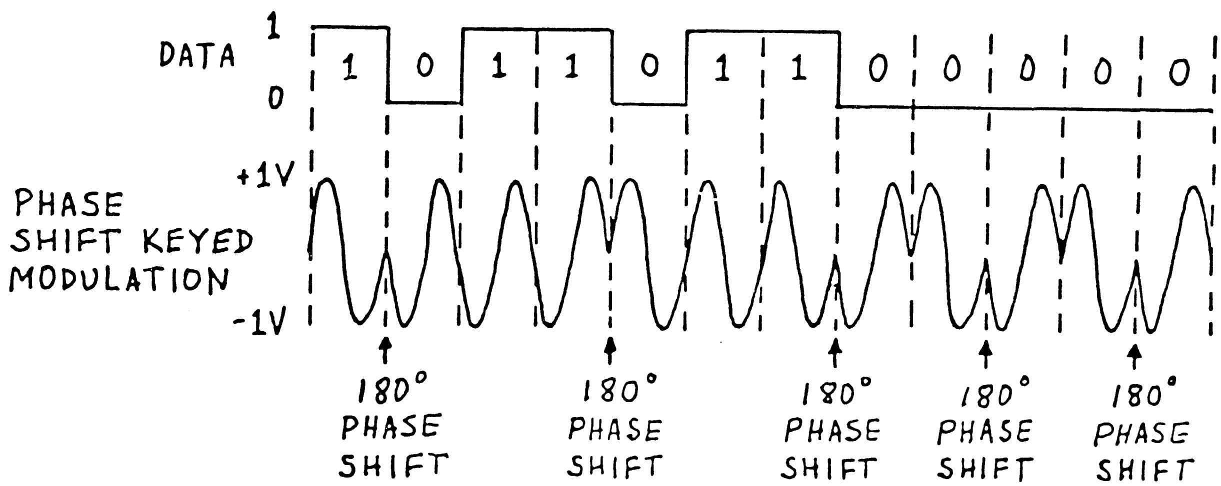
- <u>On-Off</u> <u>Modulation</u> - transmission of information on a communication line by turning a carrier signal "on" and "off." A "one" is represented by carrier "on." A "zero" is represented by carrier "off."

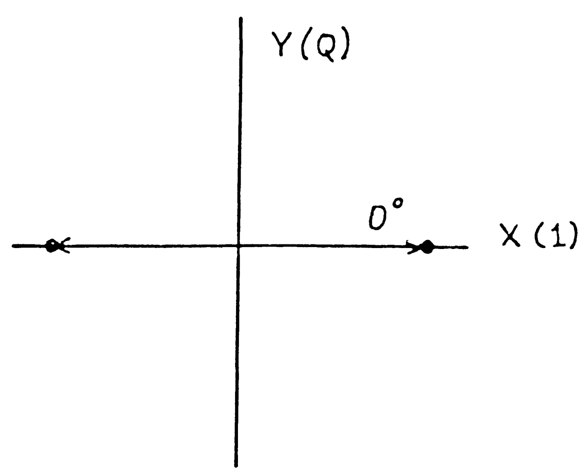


- Frequency Shift Keyed Modulation (FSK) - a form of frequency modulation (FM) in which the carrier frequency is made to vary or change in frequency precisely when a change in state of the transmitted signal occurs. A "one" is represented by a lower frequency (F1). A "zero" is represented by a higher frequency (F2). Both frequencies are at the same level.

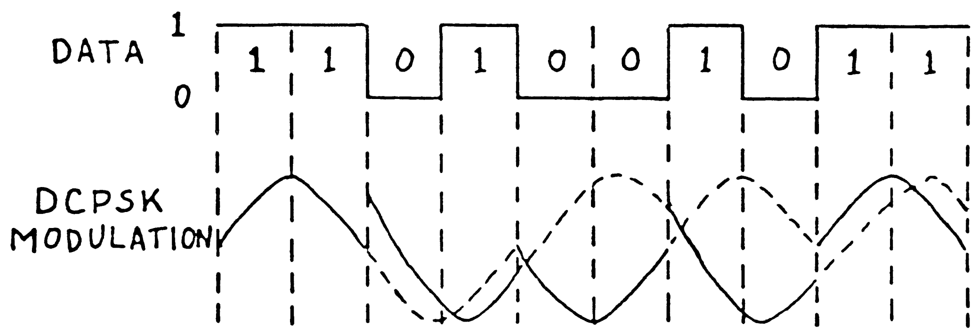


. <u>Phase</u> <u>Shift</u> <u>Keyed</u> <u>Modulation</u> (PSK) - transmission of information of a communication line by varying the phase of an analog signal in direct relationship to the digital input information. The carrier frequency is constant. A "zero" is represented by 180^0 phase shift. A "one" is no phase change of the carrier.

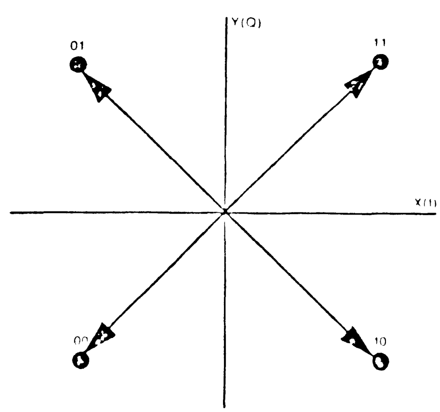




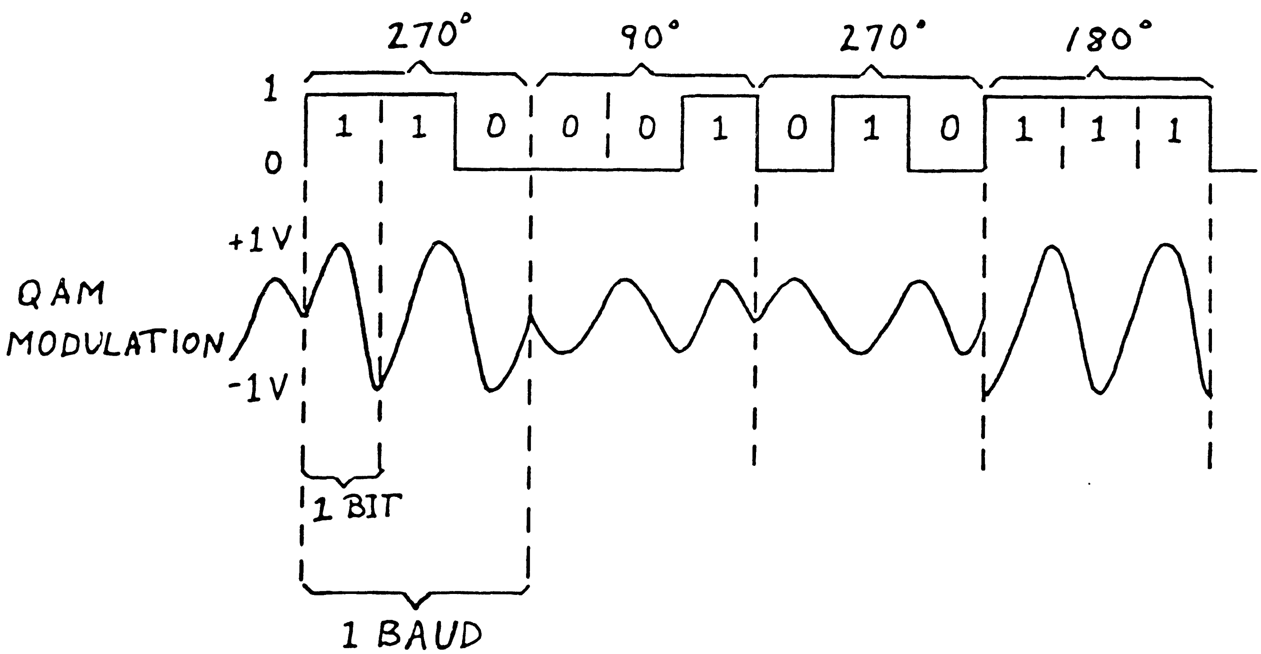
- Differentially Coherent Phase Shift Keyed Modulation (DCPSK) - transmission of information on a communication line by differentially (with respect to previously transmitted phase) vary the phase of an analog signal in direct relationship to groups of digital input information. The carrier frequency is constant. Clock information is transmitted and recovered.

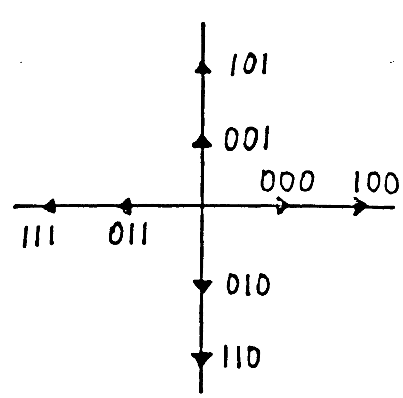


Absolute Phase	0	315	180	315	0
Δ Phase with Respect to Previous Baud	45	315	225	135	45

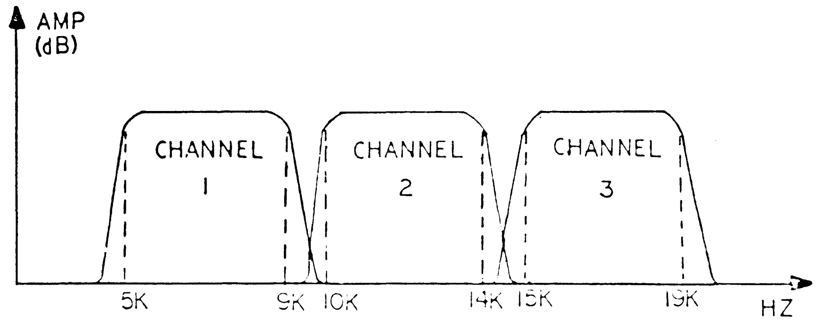


- Quadrature Amplitude Modulation (QAM) - transmission of information on a communications line by varying the phase and amplitude of an analog signal in direct relationship to groups of digital input information. The carrier frequency is constant. Clock information is transmitted and recovered. The combination of amplitude modulation (AM) with differentially coherent phase shift keying (DCPSK) creates the Quadrature Amplitude Modulation (QAM) signaling technique.

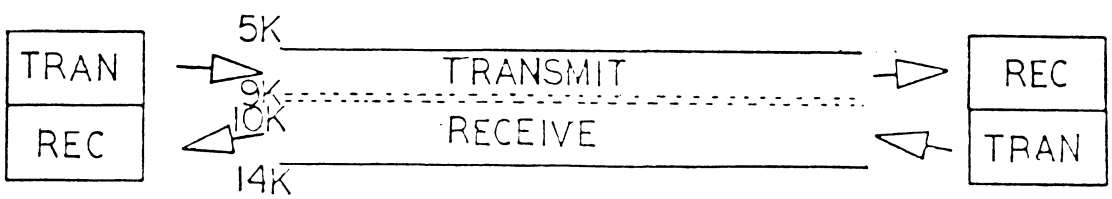




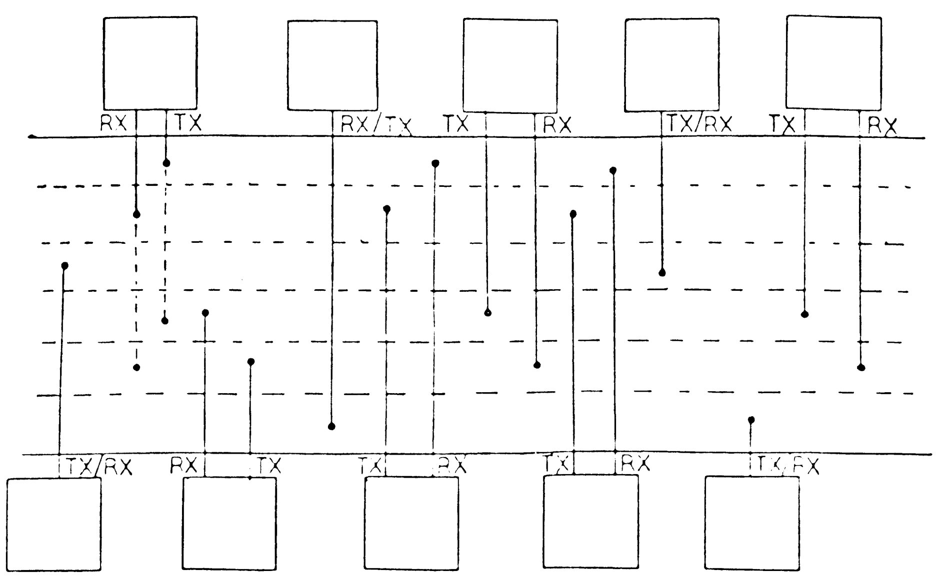
• Frequency Division Multiplexing (FDM) - a technique in which a data lines bandwidth is divided into different frequency sub-channels.



Three 4K Wide Channels



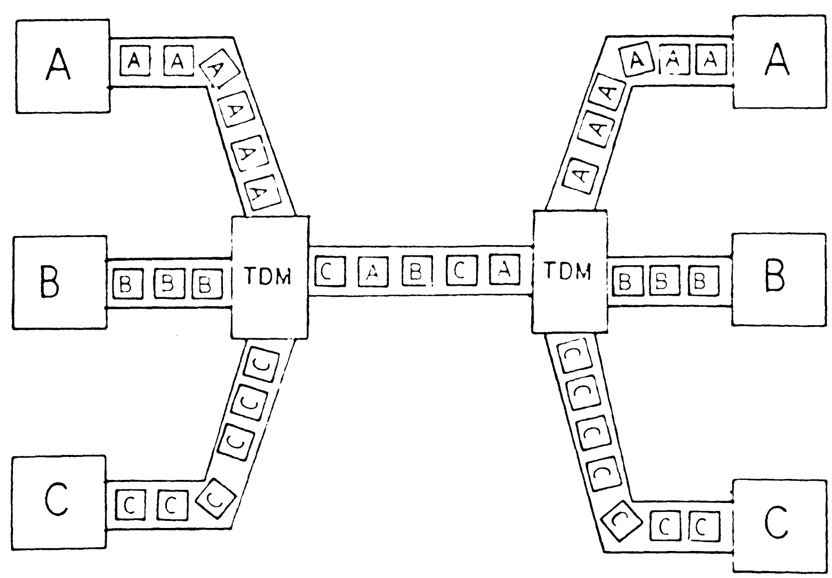
One Physical Medium - Two FDM Channels
One Transmit Channel and One Receive Channel



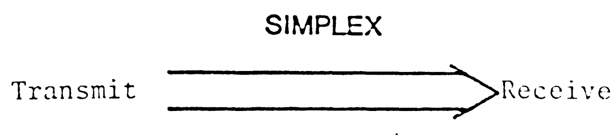
One Physical Medium Connecting Many
Devices Using FDM with Multiple Channel

- <u>Time Division Multiplexing (TDM)</u> - a multiplexing method in which time on the channel is allocated in turn to different sub-channels. The allocation may be regular in fixed cycle or frame or it may be varied according to the needs of the sub-channels.

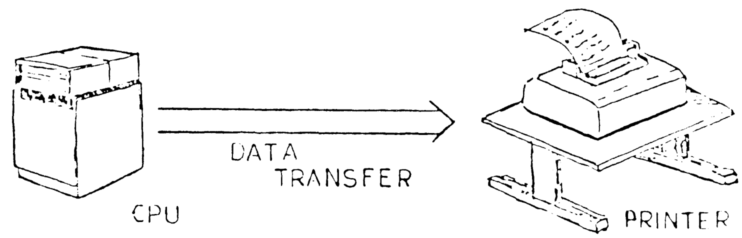
  Time division multiplexing allows a message or a portion of a message to be sent in sequence or serially, each completely occupying the complete channel capacity for the time it is turned on.



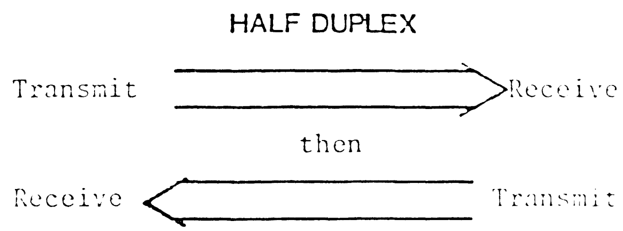
4. Modes of Transmission



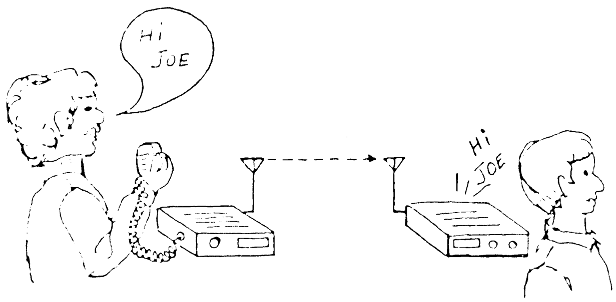
<u>Simplex</u> transmission where equipment or protocol are only capable of transmitting in one direction. An example is transmitting data to receive only printer or a TV station.



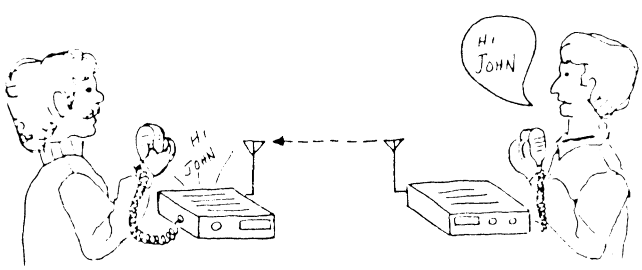
. Information transfer is in one direction only



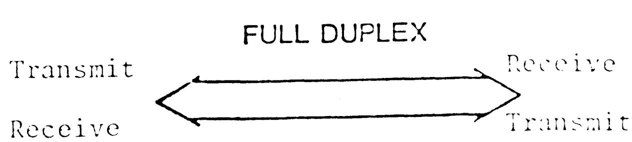
<u>Half-duplex</u>-transmission on 2 wires or employing a protocol capable of transmitting in one direction at a time. Host and remote ends take turns transmitting and receiving. An example of this mode of transmission would be operating a CB radio.



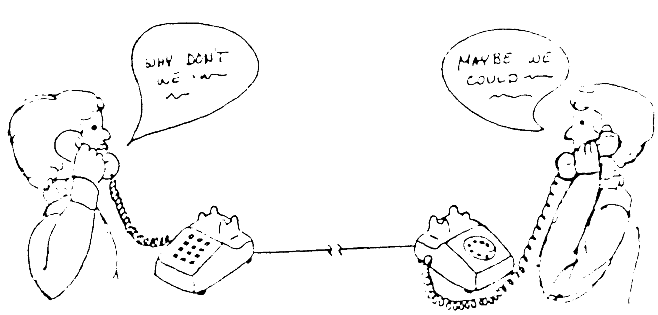
. Information transfer in both directions but only one time.



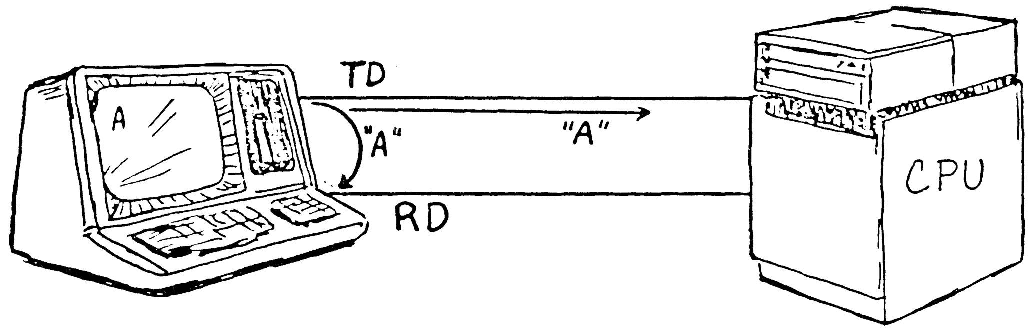
. Pressing the key on the mike is like raising RTS on the modem.



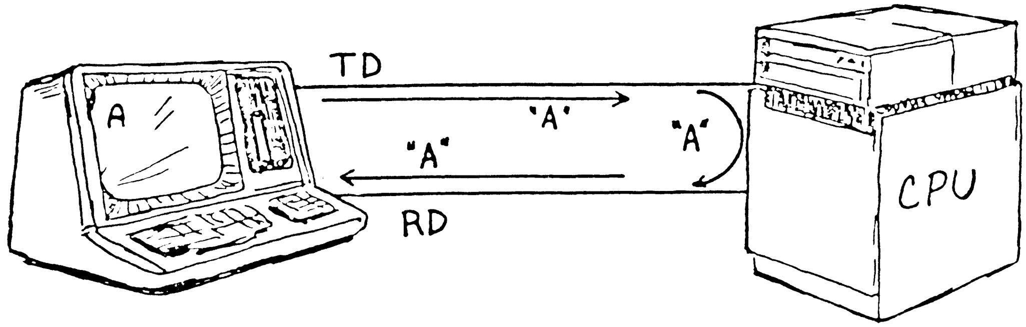
<u>Full-duplex</u> transmission on 2- or 4-wires where equipment and protocol are capable of transmitting in both directions at the same time. An example is two people talking simultaneously over the telephone.



. Information transfer is in both directions simultaneously.

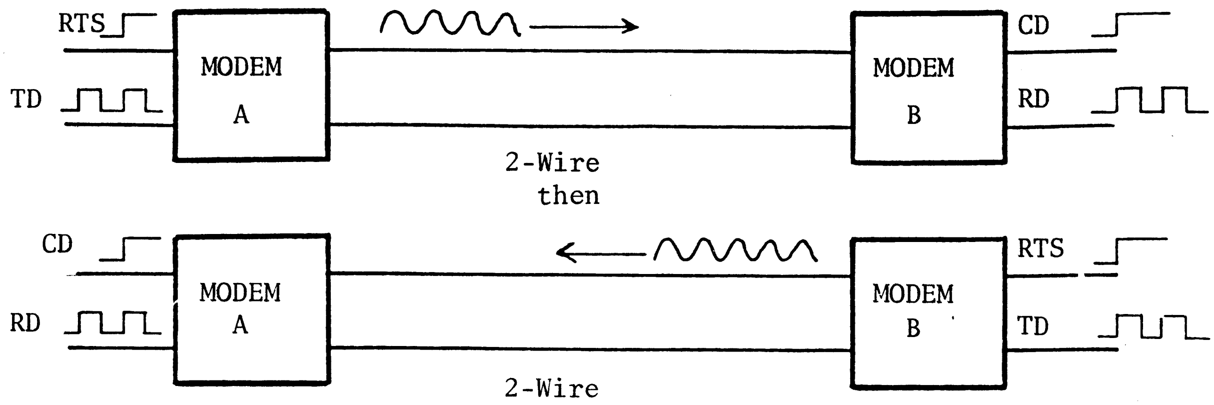


Echoplex - characters are echoed locally on the screen of the local terminal and sent out the transmit data lead to the CPU, sometimes called Half Duplex on a "dumb" terminal.

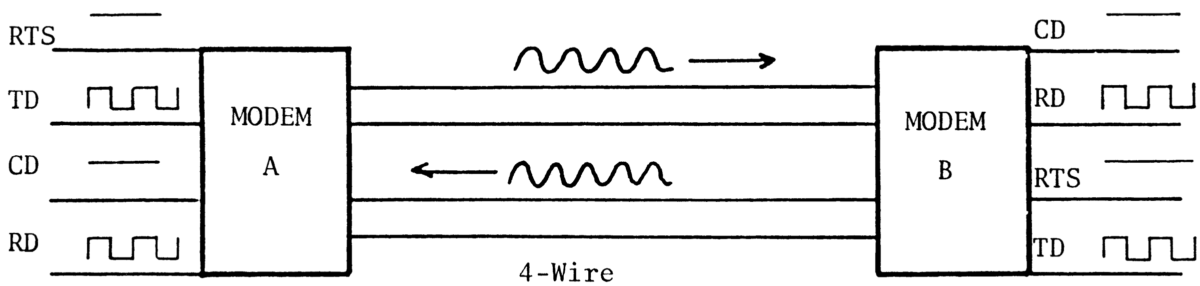


Echo - characters are echoed back from the CPU to the terminal as a means of error checking. Sometimes called Full Duplex on a "dumb" terminal.

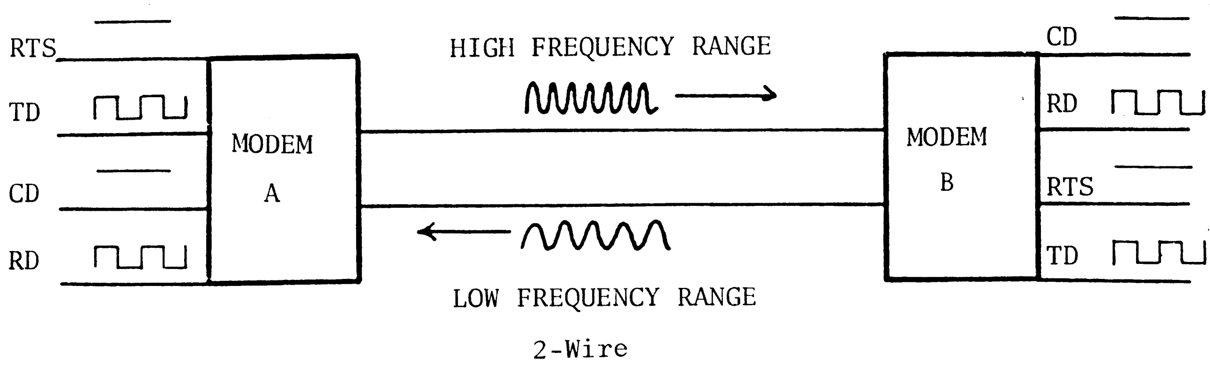
Echoplex Versus Echo



Half Duplex Modems take turn transmitting on 2-wires (Time Division Multiplexing)



Half Duplex modem transmit in both direction (full duplex) at the same time on 4-wires.



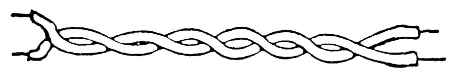
Full Duplex modems transmit in both directions at the same time on two wires by frequency Division multiplexing the transmit and receive signals.

It is important to note that the terminal equipment must be able to support half duplex operation if half duplex modems are used. Likewise, the terminal equipment must be able to support full duplex operation if full duplex modems are used.

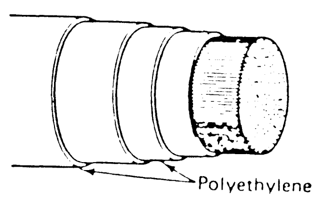
<u>Full and Half Duplex Modems</u>

E. **Types of Transmission Media**

1. Twisted Pair - pair of wires that are insulated and twisted together to minimize interference.



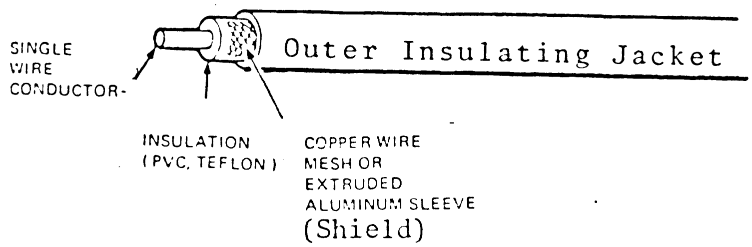
Single Twisted Pair



Cable With Multiple Twisted Pair (Trunk Line)

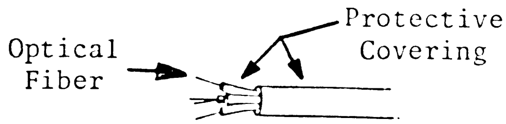
- main type of media for local telephone and data transmission
- wire is normally made of copper
- can be installed easily using commonly available tools
- short distances (normally less than 10 miles)
- bandwidth and distance limitations because of high capacitance of twisted pair (less than 256kbps at 1 mile)
- wire susceptable to electrical interference
- higher error rates
- as bit rate increases, distance that can be operated decreases
- as the cable size decreases, the speed possible decreases
- as the cable size decreases, the distance possible decreases

B. <u>Coax</u> <u>cable</u> - contains a central carrier wire surrounded by fine copper wire mesh and/or an extruded aluminum sleeve. Cable is covered with an insulating PVC outer jacket. Shield and central carrier wire are separated by an insulating material such as PVC or teflon.

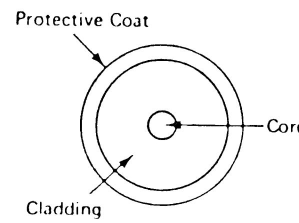


- long distances with repeaters
- wide bandwidth so it can multiplex many channels (500mHz)
- heavy, shielded cable
- support high data rates
- high immunity to electrical interference
- low incident of error
- used extensively in CATV (community antenna TV, "cable TV")
- moderate cost
- taps, controllers, splitters, couplers and repeaters are available. Use same device as used on CATV.
- used on telephone network to multiplex many long distance calls on one cable
- low capacitance
- popular medium for Local Area Networks
- used for broadband or baseband signaling on LAN's
- Available in 50ohm or 75ohm impedence

C. <u>Optical Fiber</u> - plastic or glass fibers with a light source on one end and a light detector on the other.



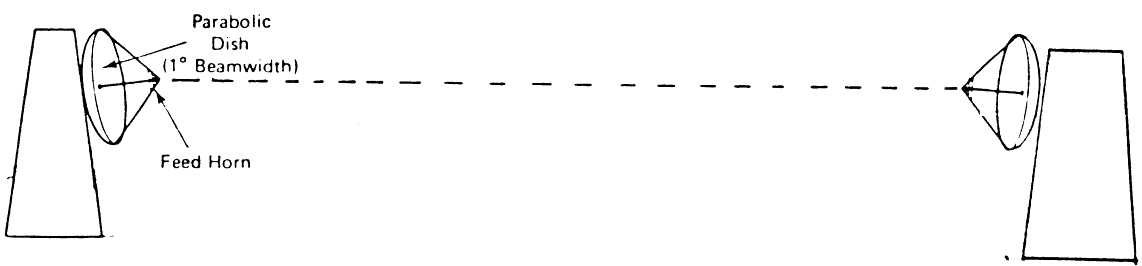
Optical Fiber
Cable



Graded Index Fibre

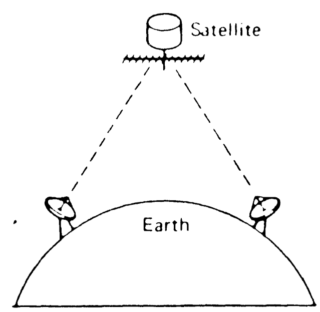
- electrical isolation
- extremely wide bandwidth (3.3 GHz)
- very high data rate (1G bps) limited by transmitter/receiver technology
- not effected by electromagnetic interference
- high security
- small and light
- very low error rate (one bit in 10^9 to 10^{10} bits)
- "T" tap currently not available. Limited to point-to-point connections.
- technology is now becoming cost effective
- telephone company now starting to use for long distance connections
- cannot be spliced in field
- cannot carry DC power

D. <u>Microwave</u> - high frequency (GHz) radio transmission/reception. Uses a parabolic dish as an antenna.



- long distances over rough terrain with repeaters
- wide bandwidth
- may be multiplexed to provide many channels over a single antenna
- affected by rain, snow and fog when frequency exceeds 10 GHz
- subject to distortion (fading and interface)
- high velocity of propagation, minimizing delay time
- can cause radio interference
- used extensively by telephone company for long distance calls (T1 carrier system)
- used in some types of LAN's and MAN's
- limited to line of sight
- used in LAN's and MAN's

E. <u>Geosynchronous</u> <u>Satellites</u> - high frequency (GHz) radio transmission/reception to and from a satellite, using a parabolic dish as an antenna.



- very wide bandwidth
- can reach almost anywhere on earth
- subject to interference from terrestrial link and to interfer with terrestrial link
- long delay times-up to 270ms
- large and costly earth transmitting antenna required
- economical receive only earth stations
- extensively used by telephone companies for long distance calls and international calls
- much lower cost per channel than submarine cable for transatlantic communications

F. Types of Public Transmission Media

(1) Private (leased or dedicated lines (3002)
- local telco leased lines are within LATA boundaries
- AT&T leased lines are within United States
- data rates less than 14.4K bps
- error rates 1 in 1,000,000 bits
- many line impairments (noise, amplitude distortion, envelope delay distortion, frequency translation, phase jitter, harmonic distortion, and phase hits)
- many standard modems available
- limited bandwidth because of loading coils

(2) Dial up lines - public switched telephone networks (PSTN)
- data rates less than 9.6K bps
- error rates - 1 in 1,000,000
- many standard modems available
- connections may be placed anywhere in the world
- many line impairments (noise, amplitude distortion, envelope delay distortion, frequency translation, phase jitter, harmonic distortion, and phase hits)
- limited bandwidth because of loading coils

(3) Telco restricted leased lines
- data rates less than 19.2K bps
- error rates - 1 in 1,000,000
- line impairments (noise, amplitude distortion and envelope delay distortion)
- no different limited distance modems available
- limited distance (20 miles)

(4) Digital Data System
- data rates are 2.4K bps, 4.8K bps, 9.6K bps, 56K bps and 1.544M bps
- between large metropolitan centers within the United States
- low error rate (99.99% error free seconds per month)
- standard Data Service Units (DSU) and Channel Service Units (CSU) available
- High reliability - less than 0.1% down time per year.
- In near future there will be a switched Digital Data System.

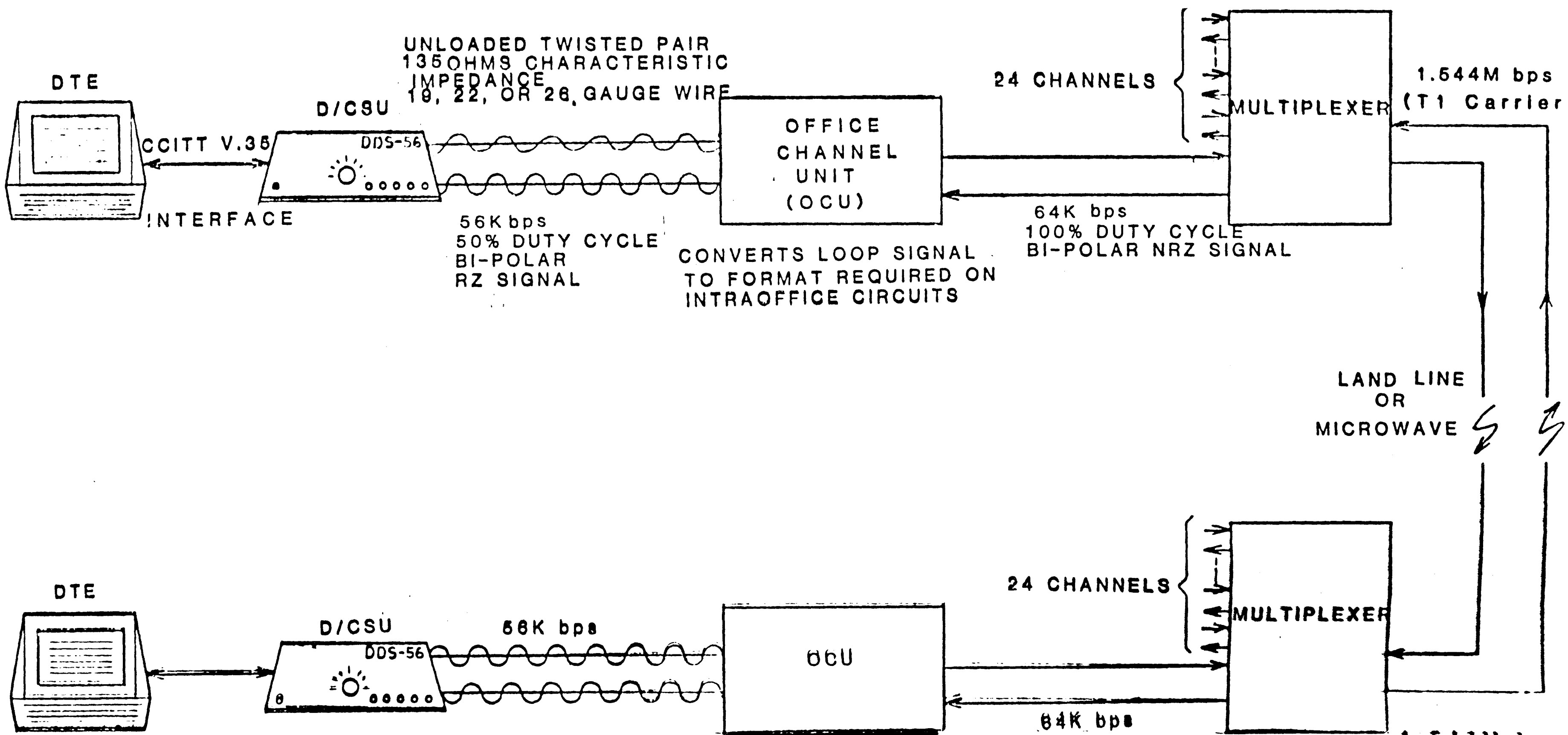
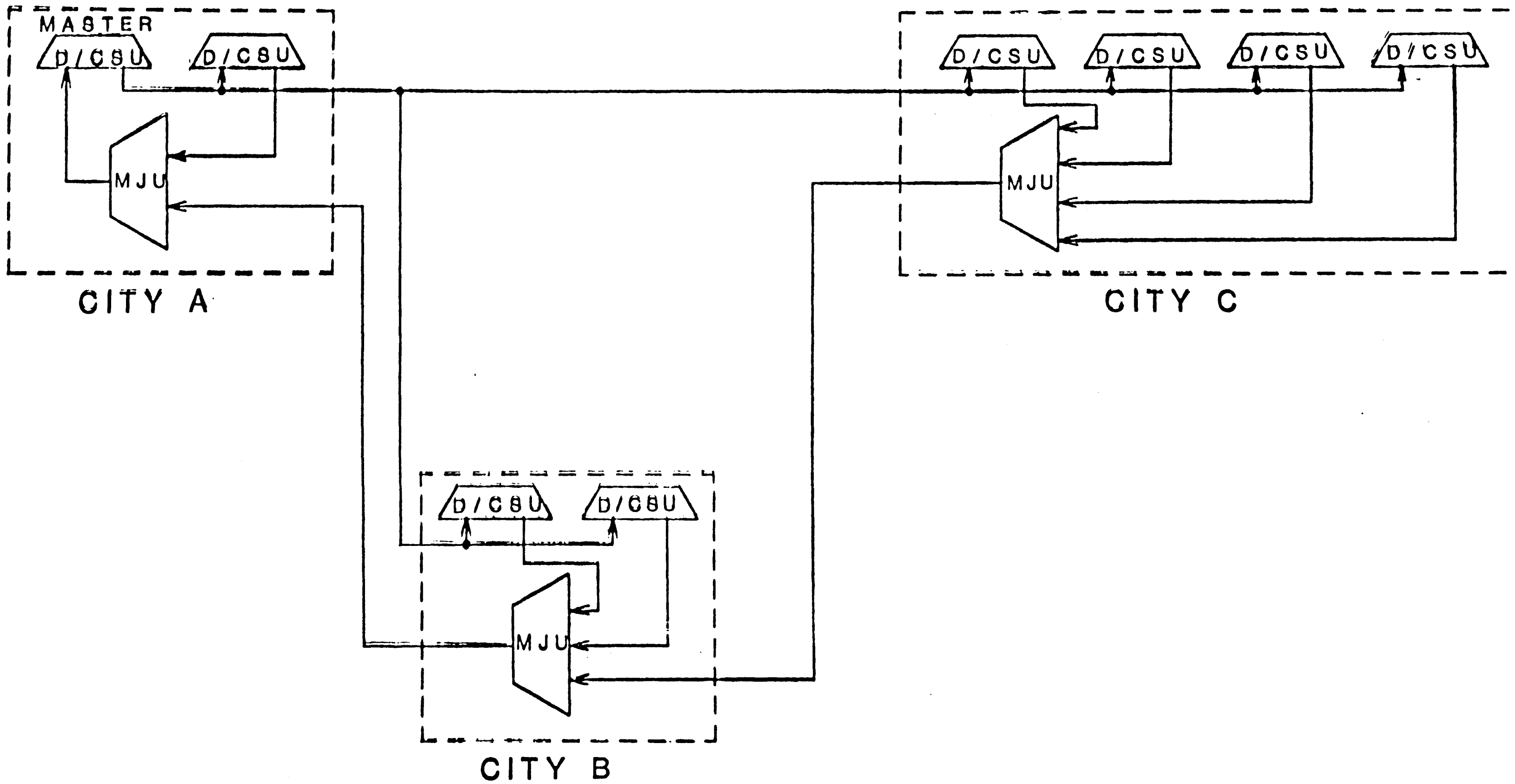


DIAGRAM OF A DDS NETWORK



BLOCK DIAGRAM OF A TYPICAL MULTIPOINT DDS CIRCUIT

SERVICE	AVAILABILITY	DISTANCE	DATA RATE	APPROXIMATE COST*	TYPES OF MODEMS
Dial-Up Lines (PSTN)	Universal	Unlimited	Up to 9600 bps Full-duplex or half-duplex	$40.00/month each end (same as normal dial-up)	103, 202S, 201C, 212A, 208B, 209, V.29
Intra LATA* Leased Lines (3002, C1, C2, C4)	Universal	Within state boundaries	Up to 14,400 bps	$3.00/mile to $15.00/mile depending on area and distance	108, 202T, 201B, 212A, 208A, 209, V.29
Inter LATA* Leased Lines (3002, C1, C2, C4)	Universal	Within U. S.	Up to 14,400 bps	$0.57/mile to $2.25/mile depending on distance & city	108, 202T, 201B, 212A, 208A, 209, V.29
Unloaded Lines (Bell 43401 and 48230)	Universal	Up to 20 miles	To 19,200 bps (9,600 bps most common)	$0.50/mile to $1.00/mile, approx. $400.00 start-up, limited availability	No standard types - Limited Distance Modems
Dataphone Digital Service (DDS)	Major Metro-politan centers	Within U. S.	To 1,544 kbps (2.4, 4.8, 9.6, and 56 kbps most common)	Dependent on speed & service-rule of thumb = same as multiple leased lines with modems (6 leased lines plus modems for 56 kbps, for example)	Data Service Unit (DSU) and Channel Service Unit (CSU)
303 Wideband 5700 Series 5800 Series 8000 Series	Metropolitan areas	Within U. S.	50 kbps or 230.4 kbps		
Twisted Pair	Install yourself	Up to 20 miles	To 256 kbps	Dependent on gauge of wire, distance, labor, costs.	No standard types. Limited Distance Modem or Line Driver

*Costs vary considerably; check with your Telco representative
*LATA - Local Access & Transport Areas

TYPES OF PUBLIC TRANSMISSION MEDIA

6. Network Topologies

A. Definitions

(1) Topologies - geometric arrangement of links and nodes that make up the network.

(2) Link - communication path between two nodes- line, channel, or circuit.

(3) Node - end points of any branch(es) or junction(s) of a network.

A node consists of hardware and/or software depending on its function in the network.

Nodes are the basic information processing units that are directly connected to a network.

Nodes are Normally single addressable entities.

(A) Intelligent user and applications oriented devices - computers, intelligent terminals, and personal workstations.

(B) Server - node which provide specific service to networks.

(C) Routing server - a system that connect nodes and networks of like architecture, that is, the architecture of a particular vender.

- dedicated system whose purpose is to offload other network nodes.
- used for connection between LAN's.
- used for connection between LAN's and long-haul networks.
- used for connection between long-haul networks of the same architecture.

(D) Gateway server - a system that connects the nodes and networks of different architecture by performing protocol translation.

- used for connections between dissimilar LAN's
- used for connections between devices on the same LAN that understand different and higher level protocols.
- used between LAN's and long-haul network of different architectures.

(E) Terminal server, printer servers, file servers - systems that provide an interface between compatible peripheral device on a LAN.

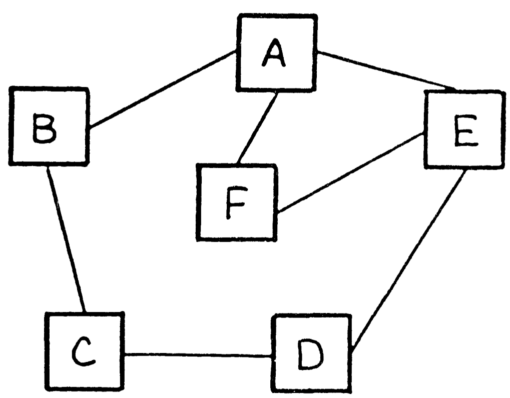
- terminal and printer servers provide EIA compatible connection for terminals and printers on a LAN.

- file servers allow sharing of mass storage devices (like disks)

- file servers can facilitate file storage, retrieveal, transfer, and maintenance function.

(4) Physical Link - actual electromechanical circuits between nodes. These links may be permanent or temporary.

(5) Logical Link - connection of two nodes that are able to communicate. They may or may not have direct physical connection.



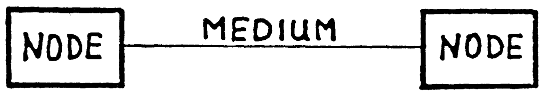
Physical links
A-B, B-C, C-D, D-E.
E-A, A-F, F-E

Logical links
B to E through A,
B to F through A,
C to F through D and E, etc. All nodes are logically linked by routing it through other nodes.

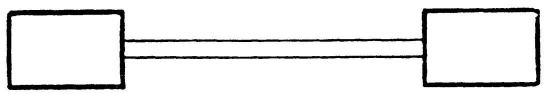
(6) Message routing - pass a message along to an adjacent node.

- eliminates the need for so many direct physical connections
- nodes must be able to make routing decisions

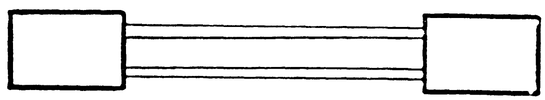
B. <u>Point to point link</u> - connect two and only two nodes without passing through intermediate node.



Point to Point Link

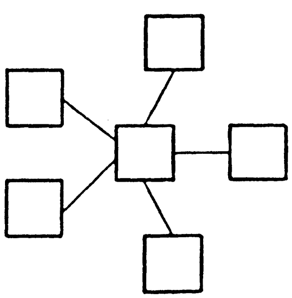


2 Wire Point to Point Link

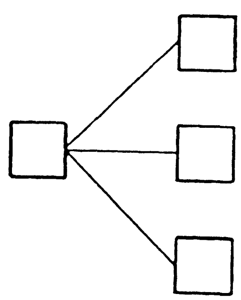


4 Wire Point to Point Link

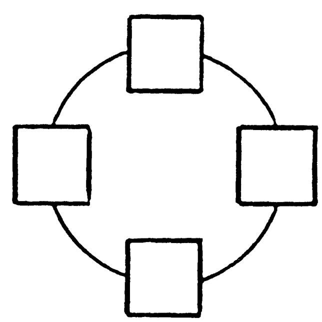
The Medium of a point to point link may consist of 2 or 4 wires.



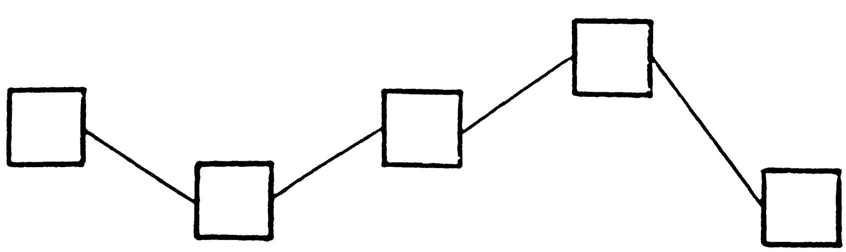
5 Point to Point Links (Star)



3 Point to Point Links



4 Point to Point Links (Ring)

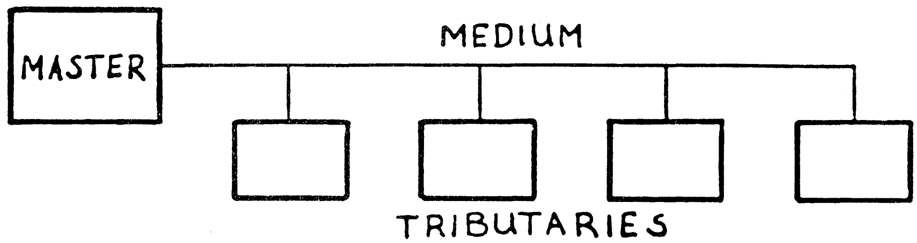


4 Point to Point Links

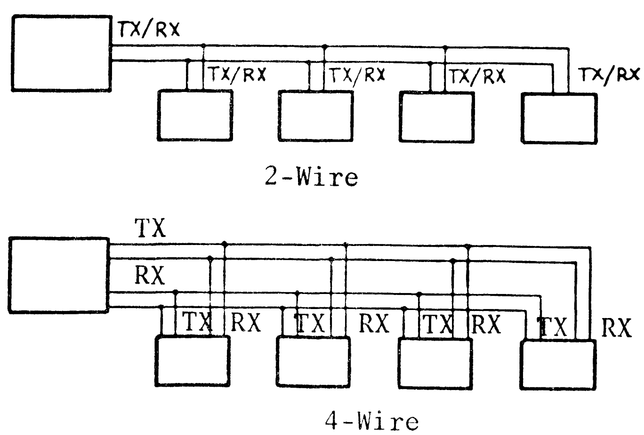
C. Multipoint or multidrop link - single line connected to more than one node.

(1) Central control - master node determines when tributaries can send messages and how long messages are sent.

- requires intelligence in master node and tributaries. (CPU and intelligent terminal devices)



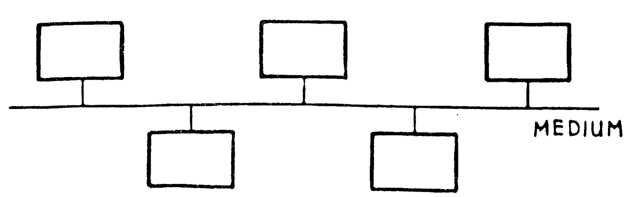
Multipoint or Multidrop with Centralized Control



The Medium of Multipoint Links may consist of 2 or 4 Wires

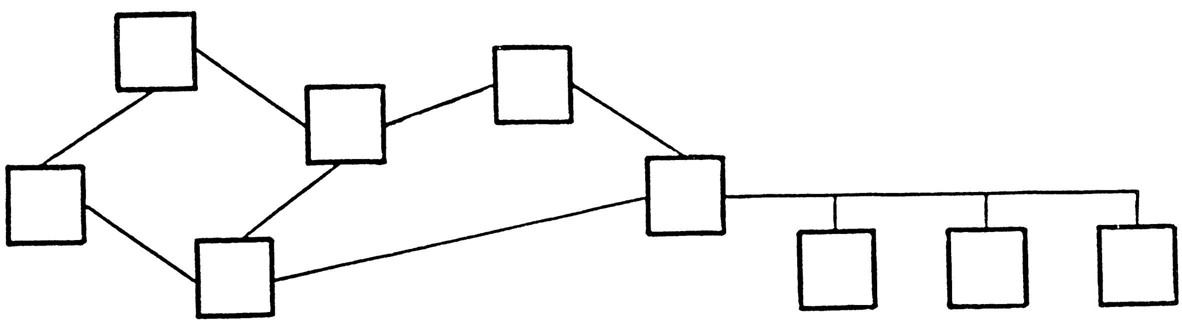
(2) Distributed control - each node has the ability to contend for the line to transmit when the line is free of message traffic.

- the rules for this type of contention set-up are implemented in each node
- can only be used with LAN's



D. <u>Mesh, hybrid, or unconstrained topologies</u> - non-specific configurations that take the shape of the actual connections.

- connections are determined by media costs, number of nodes, and system efficiency
- made up of combinations of point-to-point and multi-point link
- may use routing and non-routing nodes
- commonly used on wide area networks or long haul packet-switched networks



E. <u>Star or radial topologies</u> - all nodes are joined at a single point. Point-to-point lines connect the central and outlying nodes.

(1) <u>Central Control Node</u> -control for the network is located in the central node or switch.

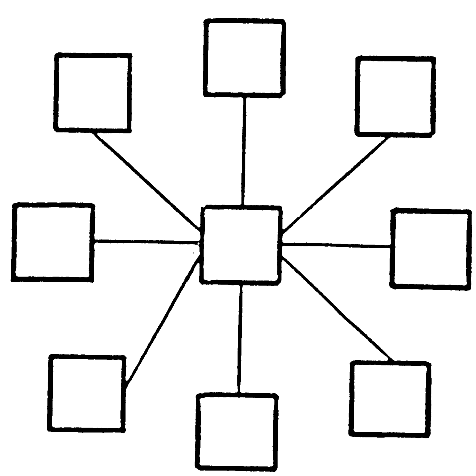
- all message routing is through the central node

(2) <u>Decentralized Control Node</u> - control of the network is through an outlying node

(3) <u>Distributed Control</u> - control of the network is distributed to all outlying nodes.

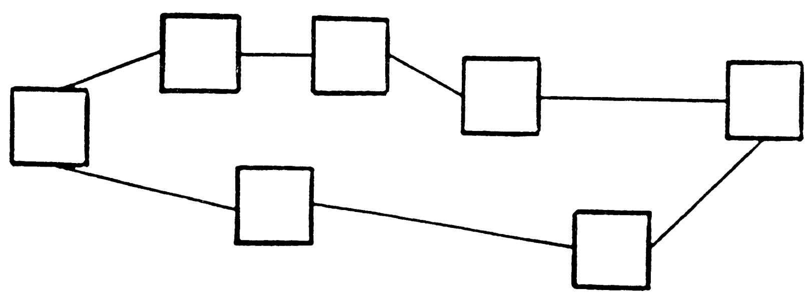
- busy signal is sent to sending node when there are no circuits available to connect to the requested node
- station busy signal is sent to sending node when available port(s) of destination node are in use.

(4) Examples of star or radial topologies.
- time sharing central host
- clustered networks - word processing clusters
- private branch exchange (PBX)



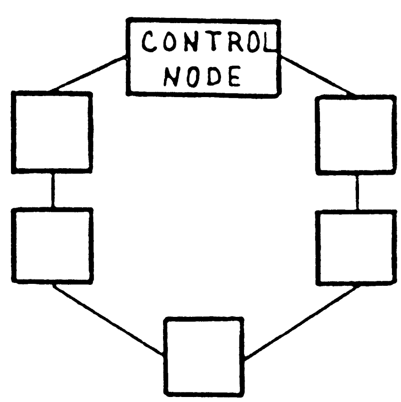
F. Ring and loop topologies - an unbroken circular configuration is formed by connected point-to-point links.

- each node is an active repeater
- transmitted messages are passed around from node to node.
- each node has its own unique address
- each node has ability to recognize its own unique address. The node accepts message that are addressed to it. All other messages are passed on.



(1) Centralized Control (Loop) - control of the ring network is from one of the nodes into the ring.

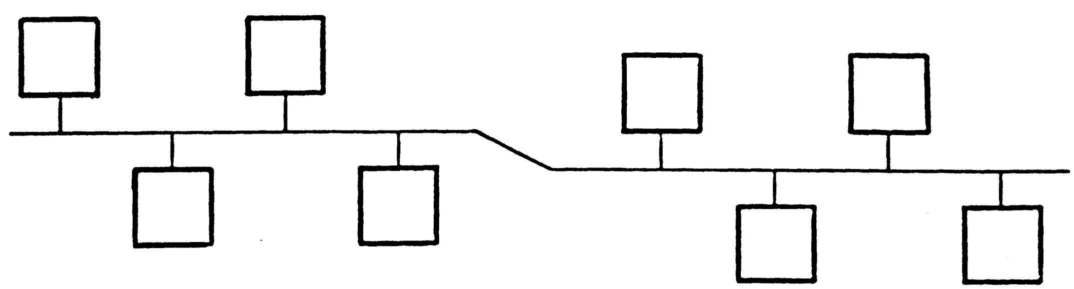
- control node tells each node when it is permitted to transmit a message



(2) (Distributed Control) Token Control - control of the ring network is distributed by passing a token (bit pattern) around the ring. A node receives exclusive access to the ring when it grabs the token. The token is then passed on to another node when it is finished transmitting.

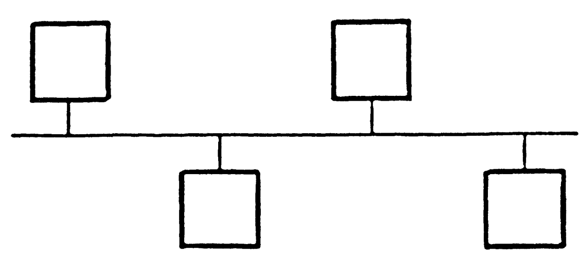
(G) Bus topologies - a network that is composed of a single line (physical channel) shared by multiple nodes.

- connectors or cable taps are used to connect the nodes to the bus
- messages placed on the bus are broadcast to all nodes
- nodes must be able to recognize their own address in order to receive messages
- nodes do not have to repeat and forward messages intended for other nodes
- nodes are relieved of network control responsibility, therefore, there is less delay and overhead in the system



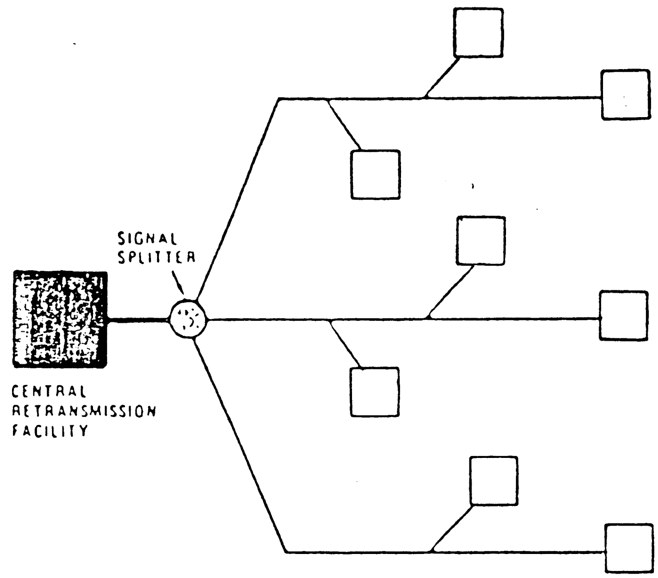
Bus Topology

(1) Single Cable Baseband Bus - used with baseband (either) local area networks. Each node contends for time on the bus.

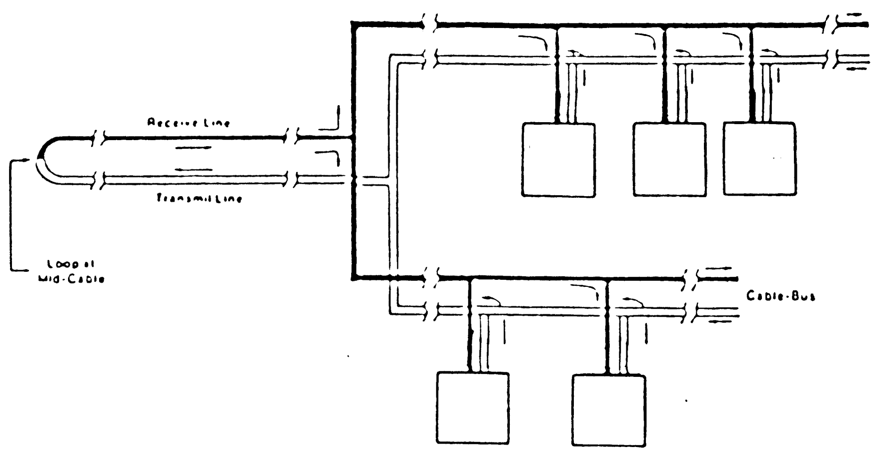


(2) Single Cable (Mid-Split) Broadband Bus - used with broadband local area network. A single cable is divided into two frequency (FDM) bands. One is for transmitting, the other is for receiving.

- Headend frequency shifter shifts transmitting frequency band to receive frequency band.

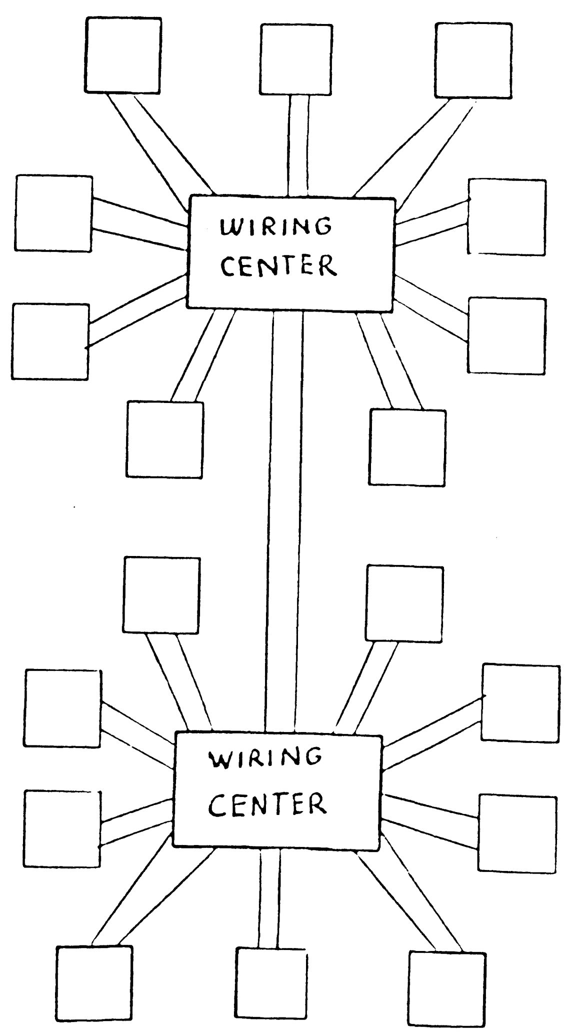


(3) Dual Cable (End-Split) Broadband Bus - used with broadband local area networks. Dual cables are connected with loop at mid cable.



H. Star Shaped Ring Topology - a network that is composed of cables from a central concentration point(s) (wiring center), to user location and back again to the wiring center.

- exhibits the benefits of both stars and rings.
- wire of data center is much like the wiring for a phone system.
- allows modification and/or servicing to be performed at the concentration point.
- can use twisted pair, coax cable, or fiber optics.

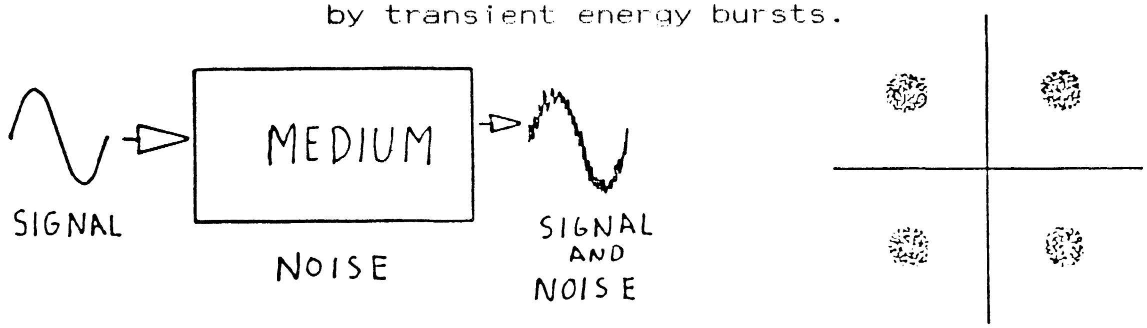


7. Media Impairments, Line Conditioning, Equalization and Performance Testing

A. Media Impairments

All communication channels are affected by disturbances that are caused by natural and/or man-made phenomena. These disturbances will have a detrimental effect on data transmission unless care is taken in the modem design to combat some or all of them.

(1) Noise - a communications line impairment inherent in the line design or induced by transient energy bursts.

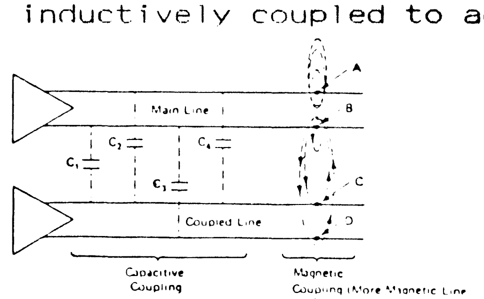


Effect of Noise on a Signal

(A) Gaussian noise (white, thermal, or shot) - noise which has a probability density function which follows the familiar bell curve. Gaussian noise is the result of many independent overlaping current or voltage pulses, such as the random motion of free electrons within a conductor. It is the background "hiss" occasionally noticeable on a telephone connection.

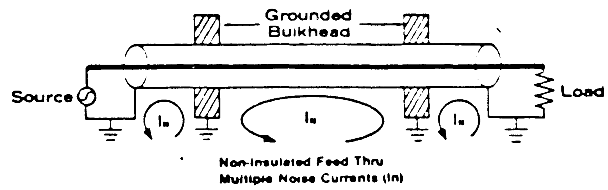
(B) Impulse Noise - a high burst of energy with durations from a few milliseconds to a hundred or more milliseconds. The noise is caused by electrical storms, switching and signaling equipment, power sources, and other electrical systems.

(C) Cross Talk - noise caused by the signal on one pair wires being capacitively or inductively coupled to adjacent wire pair.

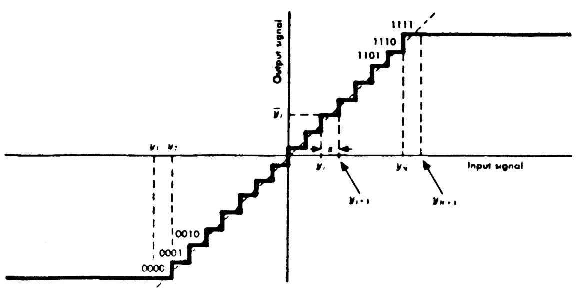


Cross Talk

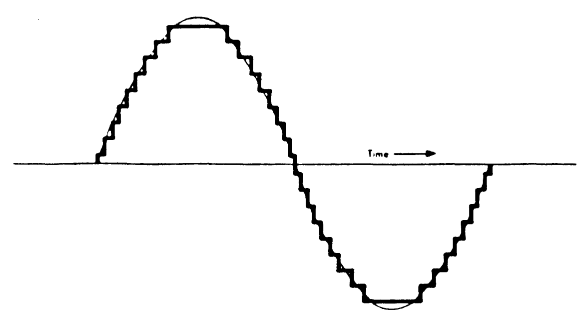
(4) Ground Loop or Common Mode Noise - caused by potential differences of external noise sources.



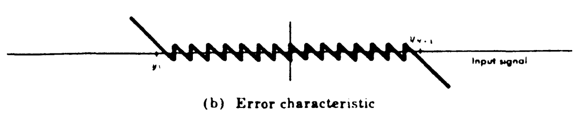
(5) Quantizing Noise - noise that is a result of the difference between the signal presented to a Codec and its equivalent quantized value. A Codec is a coder-decoder (analog to digital and digital to analog converter) that is used in pulse code modulated system such as T1 carrier.



(a) Uniform codec transfer characteristic

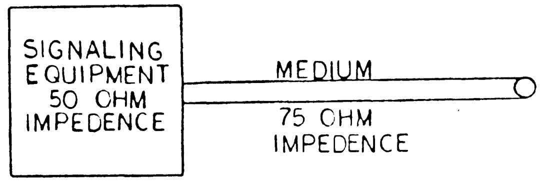


(c) Quantized full load sine wave

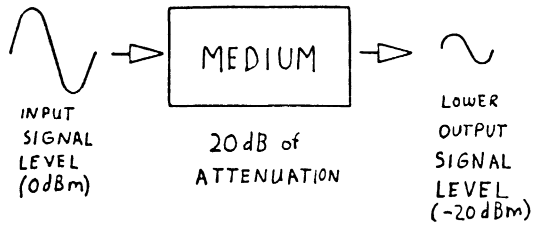


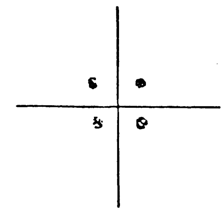
(b) Error characteristic

(6) Impedence Mismatch - the output impedence of the signaling equipment does not match the impedence of the modem. This causes signal reflections and high standing wave ratios that appear as noise in the system.



(b) Attenuation - loss of signal energy normally measured in dB.





Effect of Attenuation on Signal

- Associated signal level terminology decibel (dB) - power and voltage level measurement unit. By using the dB, dBm, dBrn, dBrnc, dBmV expressions, gains and loss along a system can be handled with simple addition and subtraction, without the need for multiplication amd division of small signal levels.

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

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

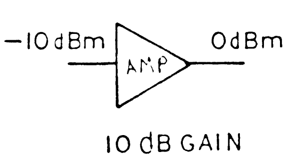
  dBm - power level measurement unit in the telephone industry based on 600 ohm impedance at 1004 Hz frequency. OdBm is 1mw at 1004 Hz terminated by 600 ohms.

  $$dBm = 10 \log \frac{P}{1mW}$$

  dBrn - power level measurement unit used in the telephone industry, - 90dBm is 0 dBrn. Maintains positive number on relative interfacing effects 0 dBrn = -90 dBm.

  C - Message Filter - a filter that is used to weight the level of noise or signal before measuring it with a dB meter. This permits measurement of the noise or signal level relative to its interfering effect on the human ear. C-Message weighting results in about 1.5dB reduction in level.

  dBrnc -power level measurement unit used in the telephone industry. Signal measured with C-Message filter, -88.5dbm is odBrnc, maintains positive number on relative interfacing effects odBrnc =-88.5dBm.

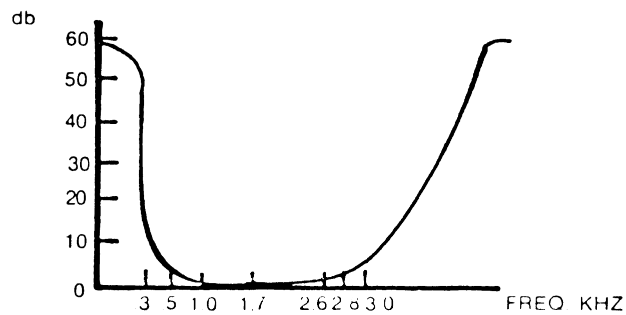


  Gain -the degree to which a signals amplitude is increased. The amount of amplification realized when a signal passes through an amplifier or repeater normally measured in decibels.

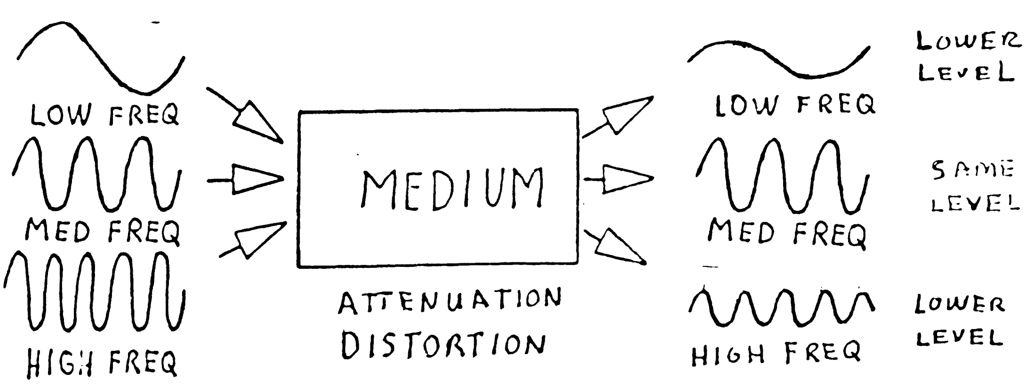
  dBmV -Power level measurement unit used in the CATV industry. OdBmV is 1000 microvolts across 75 Ohm load.

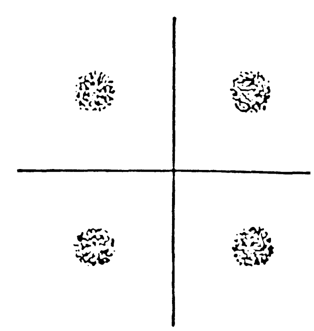
  $$dBmV = 20 \text{ Log } \frac{V}{1000 \text{ Micro Volts}}$$

(3) Attenuation Distortion - attenuation at the edges of the pass band that affects the relative magnitude of various frequency components in a transmitted signal. The causes of this distortion include capacitive and inductive reactances, filters in carrier systems, loaded cable that acts as a low pass filter, and transformers and series capacitors that act as high pass filters.



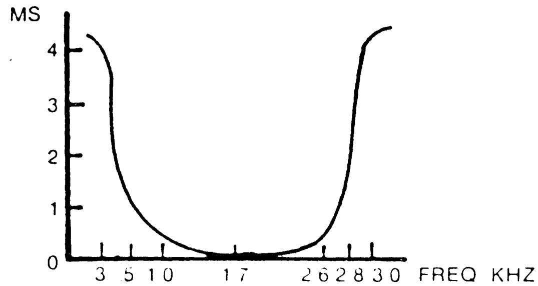
Typical Attenuation Distortion Curve



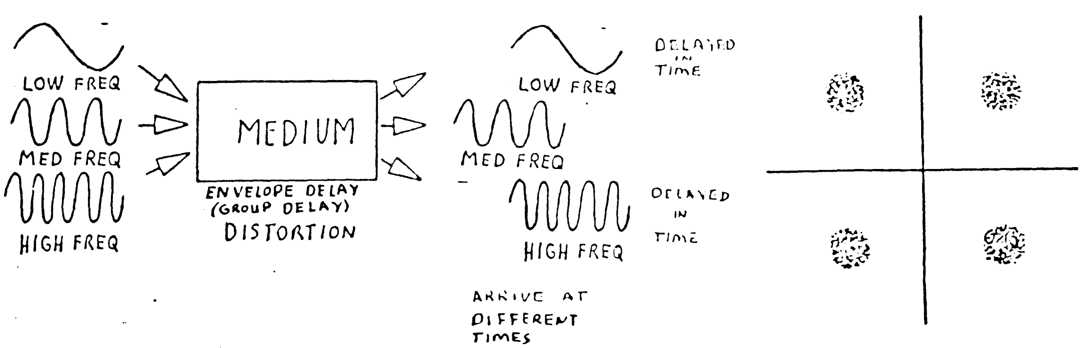


Effects of Attenuation Distortion on Signal

(4) Envelope Delay Distortion (Group Delay) - phase delays at the edges of the pass band that affect or upset the time relationship between various frequency components in a transmitted signal. Since a voice circuit acts like a bandpass filter, delay distortion increases rapidly as the filter cut-off frequency is approached. This delay is produced by the inductive and capacitive reactance in the system.



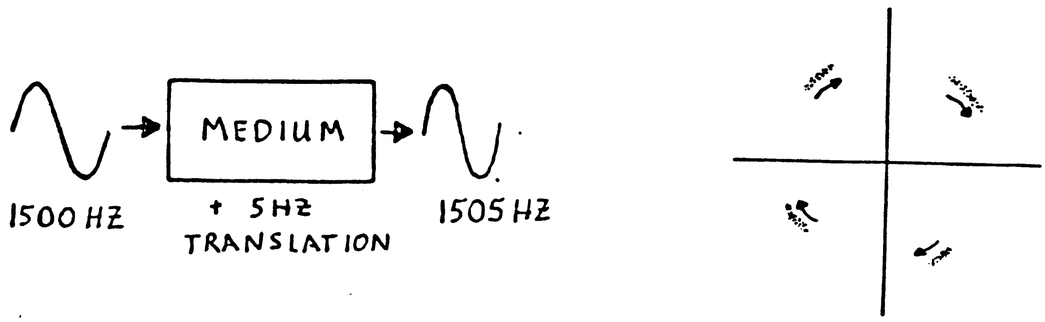
Typical Envelope Delay (Group Delay) Distortion Curve



Effect of Envelope Delay (Group Delay) on Signal

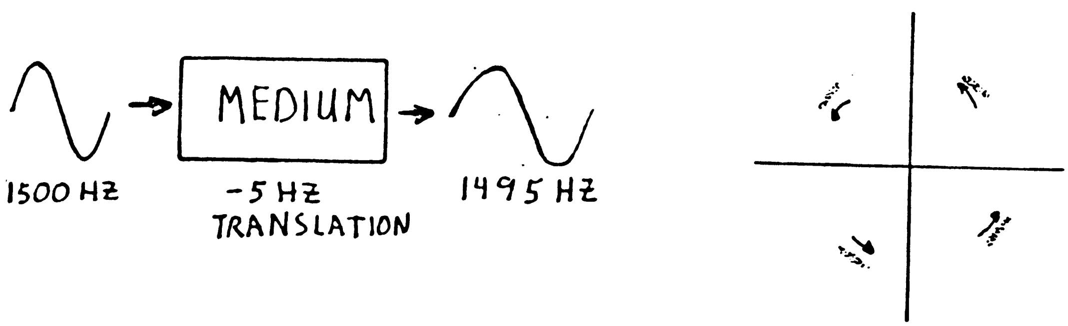
(5) Frequency Translation - a frequency shift whereby all frequency components in the modulated signal are shifted. This generally is due to oscillator drift or offset in the system carrier equipment.

Positive Translation - a shift to a higher frequency



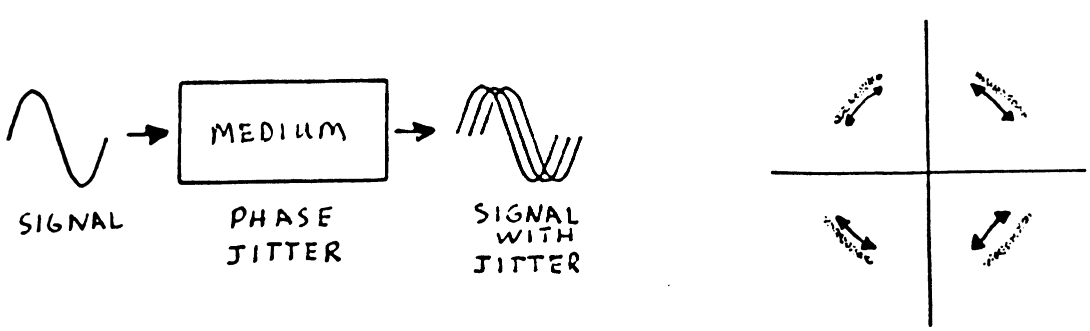
Effect of Positive Translation on Signal

Negative Translation - a shift to a lower frequency



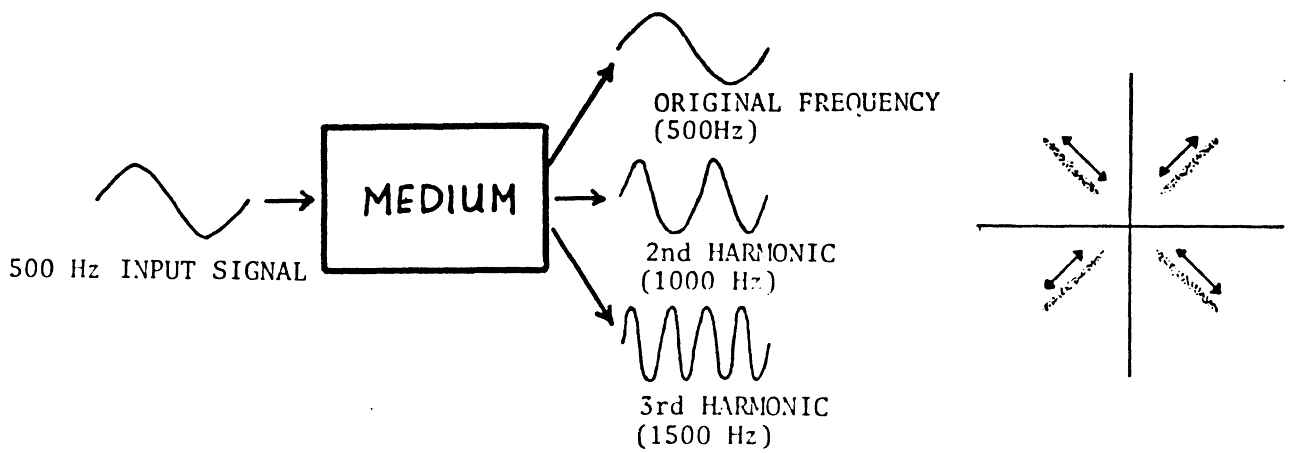
Effect of Negative Translation on Signal

(6) Phase Jitter - results in a pure tone having an associated FM spectrum. Insome cases, this spectrum is random and in other cases it takes the form of discrete, often multiples and submultiples of ac power frequencies. Phase jitter is caused by coupling through from power line associated equipment such as ringing generators.



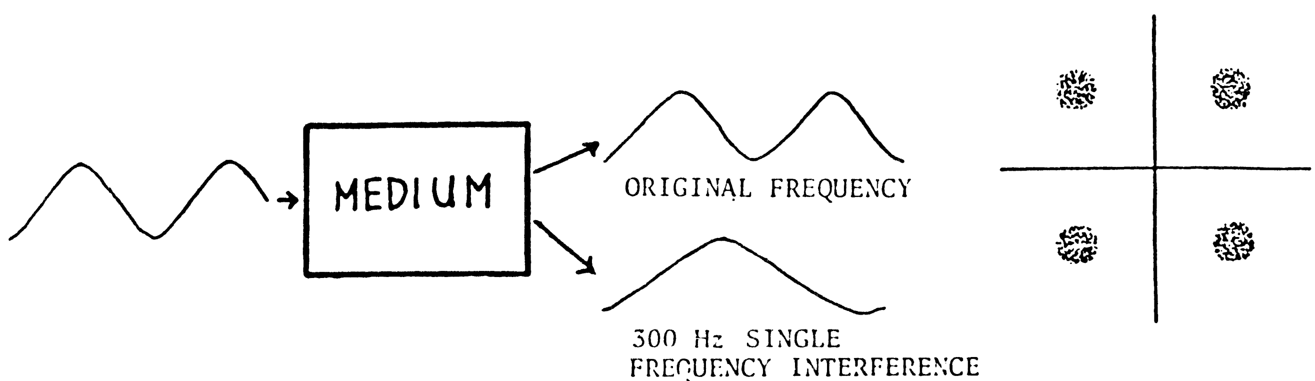
Effect of Phase Jitter on Signal

(7) Harmonic (Nonlinear) Distortion - harmonics caused by non-linearities in the telephone channel. These extraneous frequencies are caused by clipping or limiting the transmitted signal. They are related to the transmitted signal in natural numbers multiplied by the fundamental signal (i.e., 500 Hz fundamental; 1000 Hz 2nd harmonic; 2000 Hz 3rd harmonic, etc.).



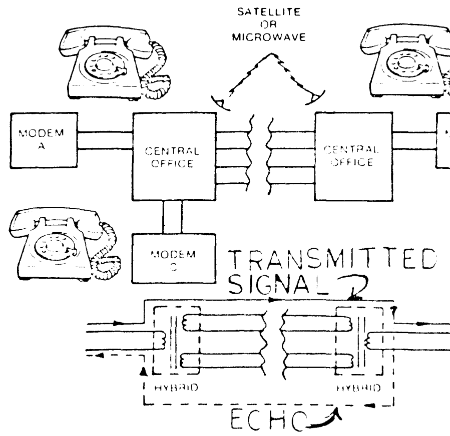
Effect of Harmonic (Nonlinear) Distortion on a Sigal

(8) Single frequency interference - addition of one or more frequencies to the signal.

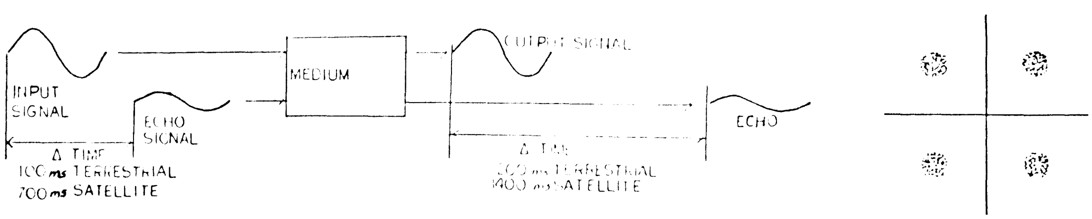


Effect of a Single Frequency Interference on a Signal

(9) Echo - a telephone line impairment on the dial up network that is caused by electrical reflections at distant points where line impedances are dissimilar.



Origin of Echo on Dial-Up Network

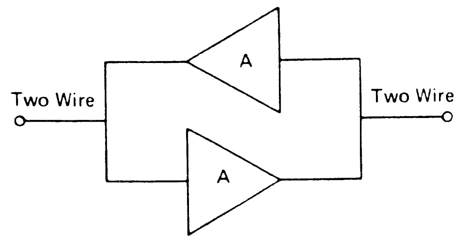


Effect of Echo on Signal

- Most telephone lines to the Central Office (CO) are two wire.

- Transmit and receive signals travel over the same electrical path within the frequency band.

- It is not feasible to put a bidirectional amplifier in the circuit because gain over unity will cause the circuit to be unstable (oscillate).

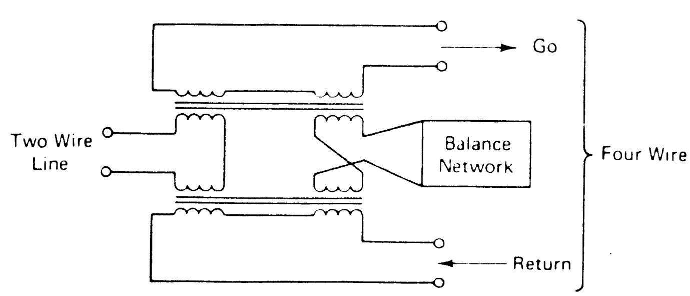


Bidirectional Amplifiers on Two Wires

Bidirectional amplifiers cannot be used on two wire circuits operating in the same transmit and receive band because gain greater than unity will cause oscillation.

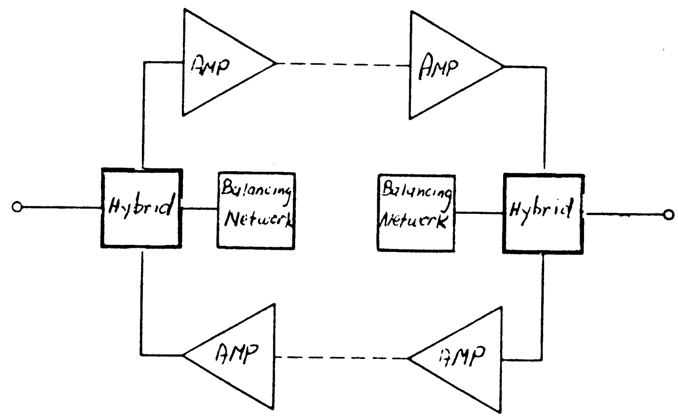
- Transmission/reception from Central Office to Central Office is normally via two separate paths. One path for transmission and the other path for receiving (4 wires).

- The device used for splitting and recombining (converting 2-wire to 4-wire and 4-wire to 2-wires) is called a hybrid or 4-wire terminating set.



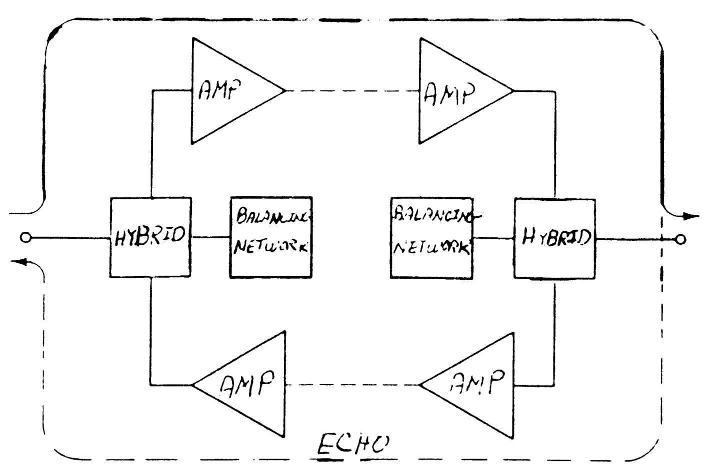
Hybrid or 4 Wire Terminating Set

- A hybrid is placed at each end of the circuit.



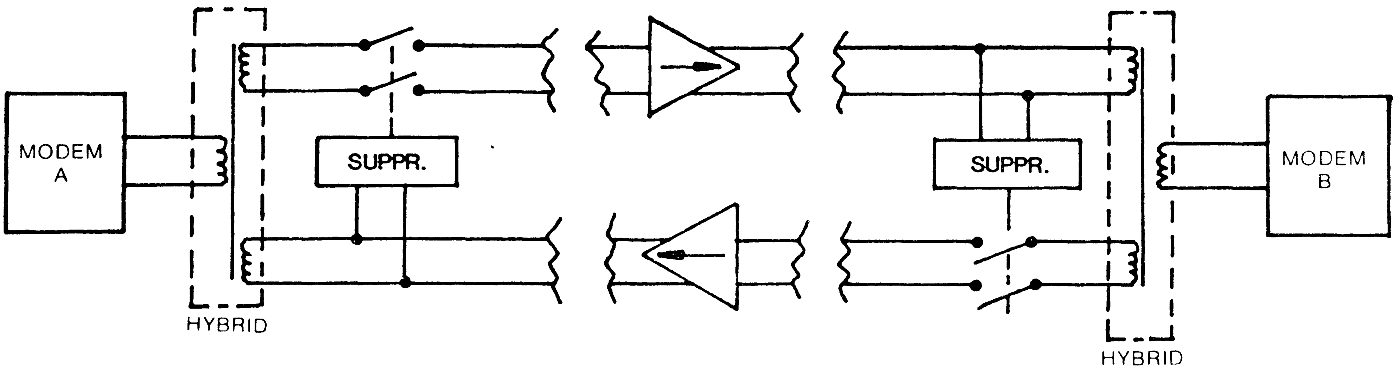
2 to 4 Wire Conversion Using Hybrids

- If the impedence is mismatched, most of the signal will reach the far end. Some of the signal will be returned as an echo to the originator of the signal.



Origin of Echo in 2 to 4 Wire Circuit Using Hybrids

Echo Suppressor - device used on terrestrial circuit (microwave) to attenuate echoes.



ECHO SUPPRESSOR
(TERESTRIAL CIRCUIT)

- Echo suppressors may be disabled (closed) using a 2125 Hz ± 100 Hz signal. This signal is called the answer back tone.

- Terrestrial circuits normally have round trip delay of less than 100ms. Therefore, the echo will be heard within 100ms.

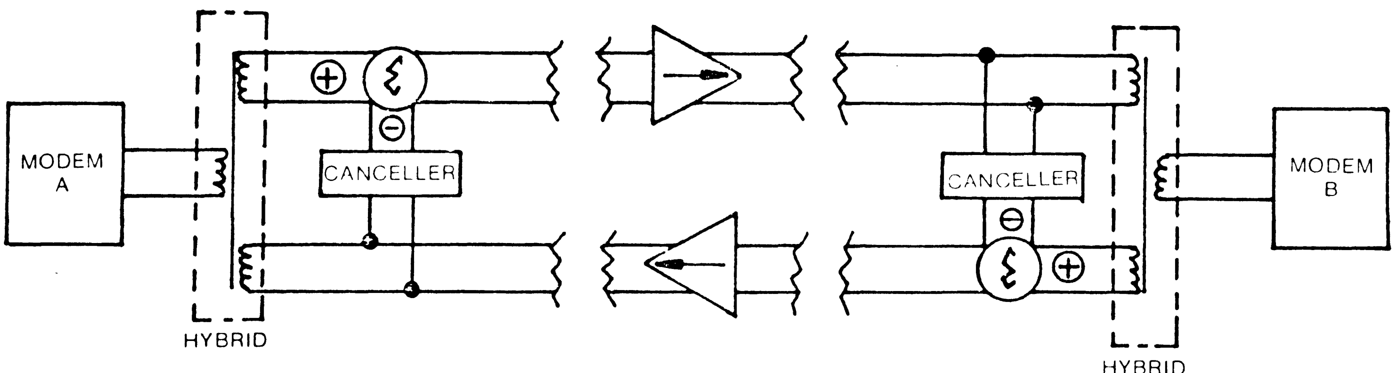
- Full duplex modems using Frequency Division Multiplexing will disable the echo suppressor with the answer back tone so that it may transmit and receive simultaneously. The Echo will not affect a FDM modem because the transmitter and receiver are operating in different frequency bands.

- Half duplex modems will often have a quiet time of two seconds after answer back tone to enable the echo suppressors. This is sometimes called a satellite option. It takes approximately 50 ms to disable (close) an echo suppressor after it has been enabled (opened). Because of the long delay required to disable (close) the echo suppressors and the long squelch delay required for echo suppression, half duplex modems will normally have a long turn around time (RTS/CTS delay - 150ms).

- Some half duplex modems have a dither or idle tone that is used to keep the echo suppressors disabled (closed). This tone is normally at 300 or 600 Hz. It is transmitted by the answering modem when a carrier is not being transmitted or received. This permits the half duplex modems to have a short turn around time (RTS/CTS delay - 30ms or 50ms). The echo will be suppressed with the modems receiver squelch.

- Echo suppressors will be replaced with echo cancellers in the future.

<u>Echo Canceller</u> - a device used on terrestrial (micro-wave) or satellite circuits to cancel echoes.



ECHO CANCELLER

(Terrestrial or Satellite Circuit)

- Satellite circuits normally have a round trip delay of less than 700ms.

- Echo cancellers are not normally enabled and disabled like echo suppressors.

- Echo cancellers are trained by incoming signals. It takes approximately 500ms to train an echo canceller. This training normally takes place during the first transmission of data.

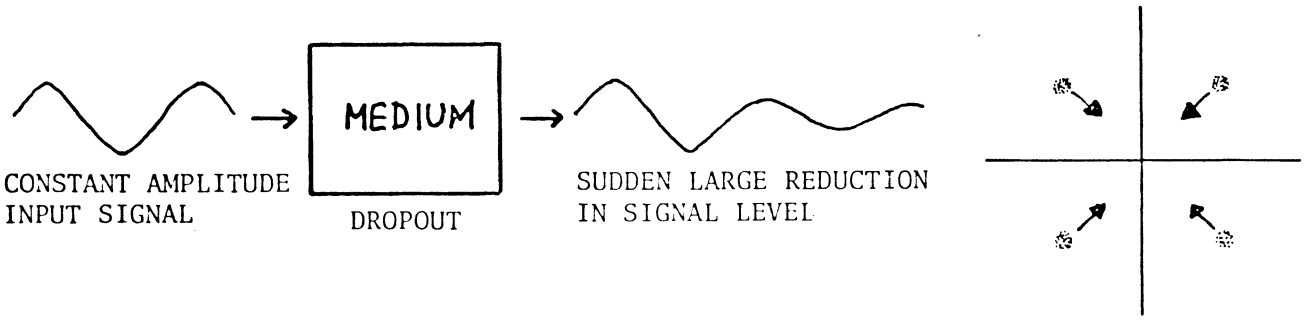
- If a signal is transmitted in both directions simultaneously (double talk mode), the echo canceller freezes (does not train). This occurs with full duplex FDM modem. The echo will not effect the FDM modem because it transmits and receives in different bands.

- Only about 5% of all connections within the Continental U. S. are by satellite. This number will decrease as these links are replaced with fiber optics.

- Intercontinental connections will most likely continue to use satellites.

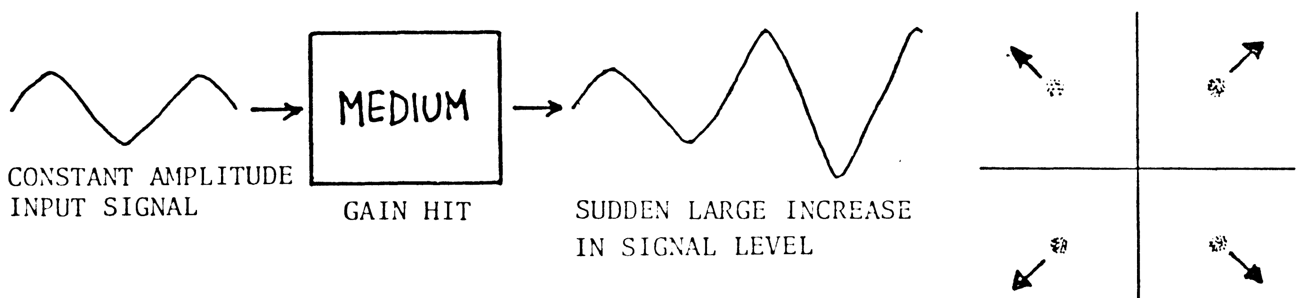
(9) Transient Impairments - impairments that are not continuously on the line.

(A) Dropouts - sudden large reductions in signal level that last for more than several milliseconds.



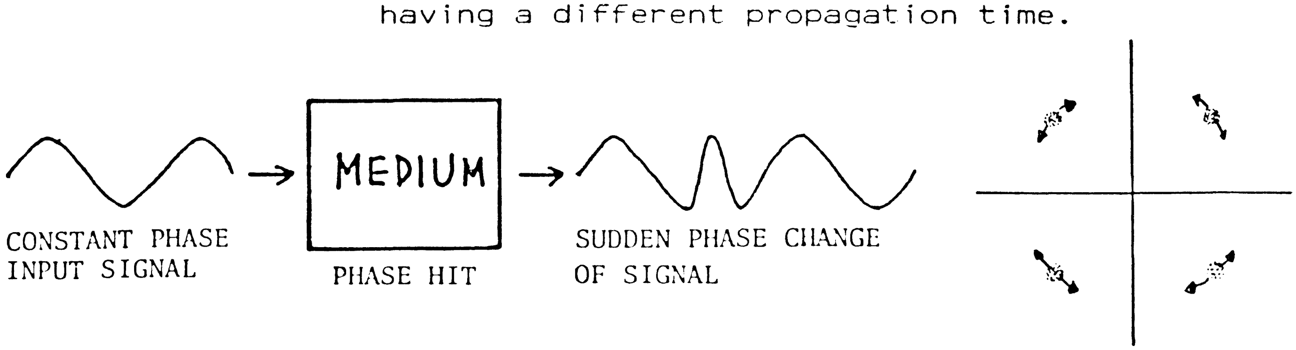
Effect of Dropouts on a Signal

(B) Gain Hits - sudden large increases in signal level that last for several milliseconds.



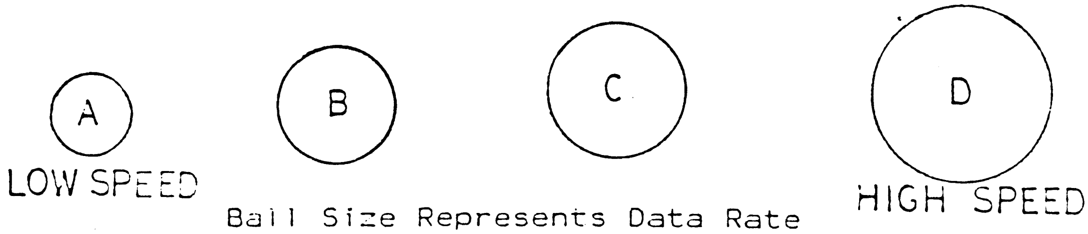
Effect of Gain Hits on a Signal

(C) Phase Hits - sudden changes in phase that are caused by the switching of out-of-phase carrier supplies or the sudden substitution of a broadband facility having a different propagation time.

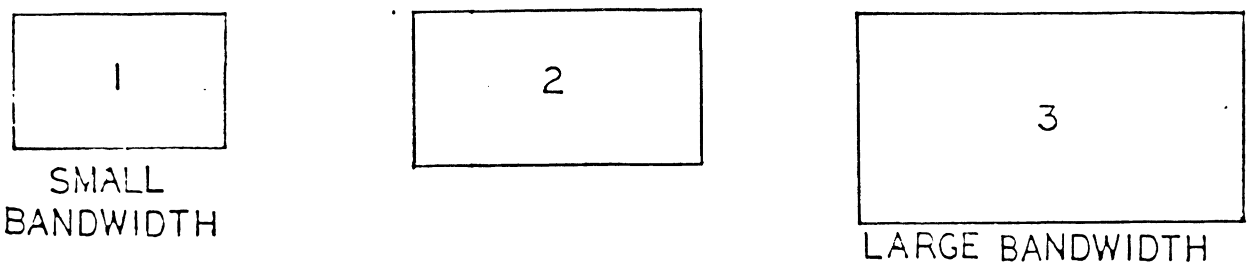


Effect of Phase Hits on a Signal

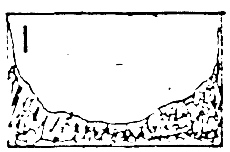
Illustration of Effect of Impairment on a Signal Using Balls and Boxes



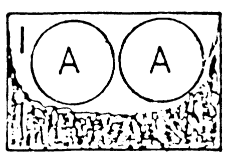
Ball Size Represents Data Rate



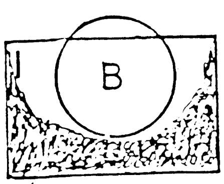
Box Size Represents Bandwidth of Medium



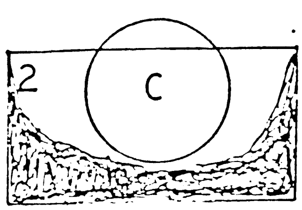
Sand in box represents medium Impairments

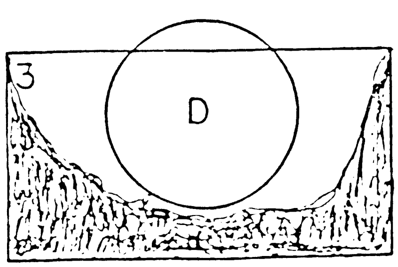


Low speed is virtually unaffected by impairments



Higher speeds are greatly effected by impairments. High speed devices will work very poorly if line impairments are not corrected or compensated for.





B. Line Conditioning

<u>Conditioning</u> - applying electronic filtering elements to a communications line to improve its ability to support higher transmission data rate.

- only available on private leased (dedicated) lines.

- <u>Unconditioned 3002</u>
  - Insertion loss specified
  - Attenuation distortion specified
  - Envelope delay (group delay) distortion specified
  - Impulse noise characteristics specified
  - Most modems will work on 3002 unconditioned lines because of equalizers contained internal to the modem

- <u>C-Conditioned</u>
  - C1, C2, C4 conditioning available
  - Improved characteristics over unconditioned lines
  - Higher tariff
  - Insertion loss specified
  - Attenuation distortion specified
  - Envelope delay (group delay) distortion specified
  - Impulse noise characteristics specified
  - most modems do not require C-conditioning
  - 202T requires C2 conditioning if it is to be operated at 1800bps

- <u>D-Conditioned</u>
  - D1 is for point to point networks
  - D2 is for multi-points networks
  - Signal to C-notched noise ratio -28dB
  - Signal to second harmonic ratio -35dB
  - Signal to third harmonic ratio - 40dB

SPECIFICATIONS FOR THE VOICE BANDWIDTH DATA CHANNEL AND C TYPE CONDITIONING

	3002 CHANNEL	C1 CONDITIONING	C2 CONDITIONING	C4 CONDITIONING
I. CIRCUIT DESIGNATION USE (NOTE D + G)	ALTERNATE VOICE/DATA OR DATA ONLY	ALTERNATE VOICE/DATA OR DATA ONLY	ALTERNATE VOICE/DATA OR DATA ONLY	ALTERNATE VOICE/DATA OR DATA ONLY
INTERSTATE TARIFF FCC NO. 260				
II. GENERAL CHARACTERISTICS				
TYPE OF SERVICE	2-POINT OR MULTIPOINT	2-POINT OR MULTIPOINT	2-POINT OR MULTIPOINT	2-POINT OR 3-POINT (NOTE F)
MODE OF OPERATION	HALF- OR FULL-DUPLEX	HALF-OR FULL-DUPLEX	HALF- OR FULL DUPLEX	HALF- OR FULL-DUPLEX
METHOD OF TERMINATION	2-WIRE OR 4-WIRE	2-WIRE OR 4-WIRE	2-WIRE OR 4-WIRE	2-WIRE OR 4-WIRE
IMPEDE SOURCE & LOAD	600 OHM RESISTIVE BAL.	600 OHM RESISTIVE BAL.	600 OHM RESISTIVE BAL.	600 OHM RESISTIVE BAL.
MAXIMUM SIGNAL POWER (NOTE H)	0 DBM FOR COMPOSITE DATA SIGNAL, OVU FOR VOICE	0 DBM FOR COMPOSITE DATA SIGNAL, OVU FOR VOICE	0 DBM FOR COMPOSITE DATA SIGNAL, OVU FOR VOICE	0 DBM FOR COMPOSITE DATA SIGNAL, OVU FOR VOICE
III. ATTENUATION CHARACTERISTICS				
MEASUREMENT BETWEEN 600 OHM IMPEDANCES AT LINEUP (RECOMMENDED)	16 DB = 1 DB 1000 HZ	16 DB = 1 DB 1000 HZ	16 DB = 1 DB 1000 HZ	16 DB = 1 DB 1000 HZ
EXPECTED MAX. VAR. OF (L) (NOTE A)	SHORT TERM = 3 DB LONG TERM = 4 DB	SHORT TERM = 3 DB LONG TERM = 4 DB	SHORT TERM = 3 DB LONG TERM = 4 DB	SHORT TERM = 3 DB LONG TERM = 4 DB
FREQUENCY RESPONSE (REF. 1000 HZ) (NOTE B)	FREQ RANGE VAR. DB 300-3000, -3 TO +12 500-5000, -2 TO +8	FREQ RANGE VAR. DB 300-3000, -2 TO +6 1000-2400, -1 TO +3 2700-3000, -3 TO +12	FREQ RANGE VAR. DB 300-3000, -2 TO +6 500-2800, -1 TO +3	FREQ RANGE VAR. DB 300-3200, -2 TO +3 500-3000, -2 TO +3

	3002 CHANNEL	C1 CONDITIONING	C2 CONDITIONING	C4 CONDITIONING
IV. DELAY CHARACTERISTICS				
FREQUENCY ERROR	±5 HZ	±5 HZ	± 5 HZ	±5 HZ
ABSOLUTE DELAY (NOTE C)	NOT SPECIFIED	NOT SPECIFIED	NOT SPECIFIED	NOT SPECIFIED
ENVELOPE DELAY DISTORTION	LESS THAN 1750 MICRO-SECONDS OVER BAND FROM 800 TO 2600 HZ	LESS THAN 1000 MICRO-SECONDS OVER BAND FROM 1000 TO 2400 HZ LESS THAN 1750 MICRO SECONDS OVER BAND FROM 800 TO 2600 HZ	LESS THAN 500 MICRO-SECONDS 1000-2600 HZ LESS THAN 1500 MICRO-SECONDS 600-2600 HZ LESS THAN 3000 MICRO-SECONDS 500-2800 HZ	LESS THAN 300 MICRO-SECONDS 1000-2600 HZ LESS THAN 500 MICRO-SECONDS 800 TO 2800 HZ LESS THAN 1500 MICRO-SECONDS 600-3000 HZ LESS THAN 3000 MICRO-SECONDS 500-300 HZ
V. NOISE CHARACTERISTICS				
MESSAGE CIRCUIT NOISE	SEE TABLE III	SEE TABLE III	SEE TABLE III	SEE TABLE III
IMPULSE NOISE (NOTE E & H)	15 COUNTS IN 15 MINUTES @69 DBM VB (69 DBM C)	15 COUNTS IN 15 MINUTES @69 DBM VB (69 DBM C)	15 COUNTS IN 15 MINUTES @69 DBM VB (69 DBM C)	15 COUNTS IN 15 MINUTES @69 DBM VB (69 DBM C)

NOTE: *THESE SPECIFICATIONS ARE TARIFFED ITEMS. ALL OTHERS ARE THE CURRENT ADMINISTRATIVE INSTRUCTIONS OF A.T. & T. CO.

A. (L) is the net loss as measured at 1000 Hz. Short-term variations are those likely to be observed during a measurement interval. They are caused by amplitude and phase shifts, dropouts, and maintenance activities. Long-term variations include seasonal changes, tube aging, etc.

B. DC continuity is not provided on any of these offerings.

C. Absolute delay and propagation times are not specified. Where satellite channels are employed, the delay may be several tenths of a second and telemetry and retransmission schemes may be either unusable or limited.

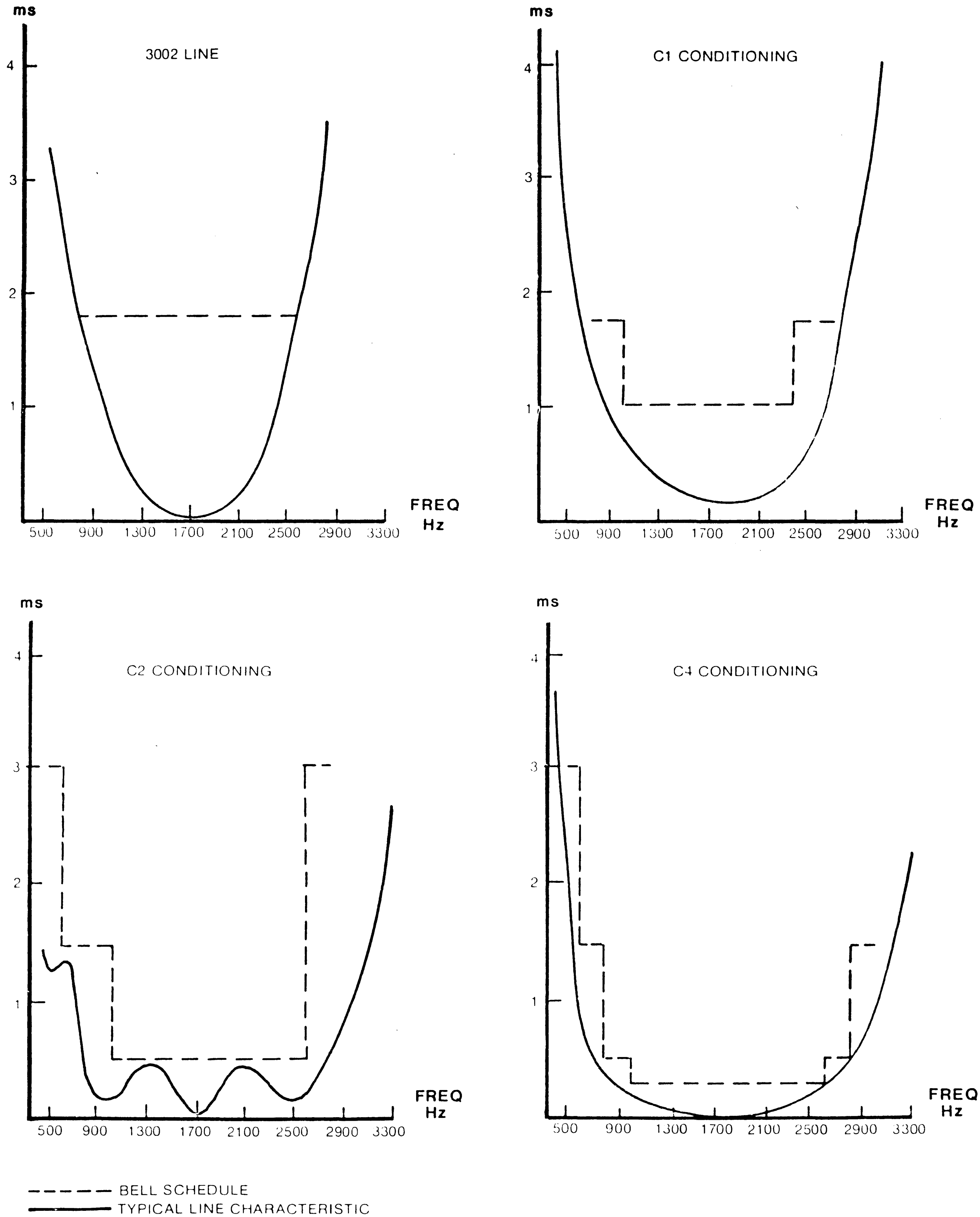
D. If alternate voice data operation is desired and the data modulation does not allow the use of compandors (such as many AM systems where instantaneous power varies rapidly), the voice mode may be degraded by excessive noise. If signalling is required, the data modulation must not interfere with 2600 Hz S.F. signalling units and response is not specified between 2450 and 2750 Hz.

E. These impulse noise limits are primarily plant maintenance limits. In cases where they are exceeded, Engineering will evaluate the performance on impulse noise distribution, i.e., how rapidly the counts (impulses) fall off as counting level (impulse noise peak voltage) is raised, and the effect on the data system performance.

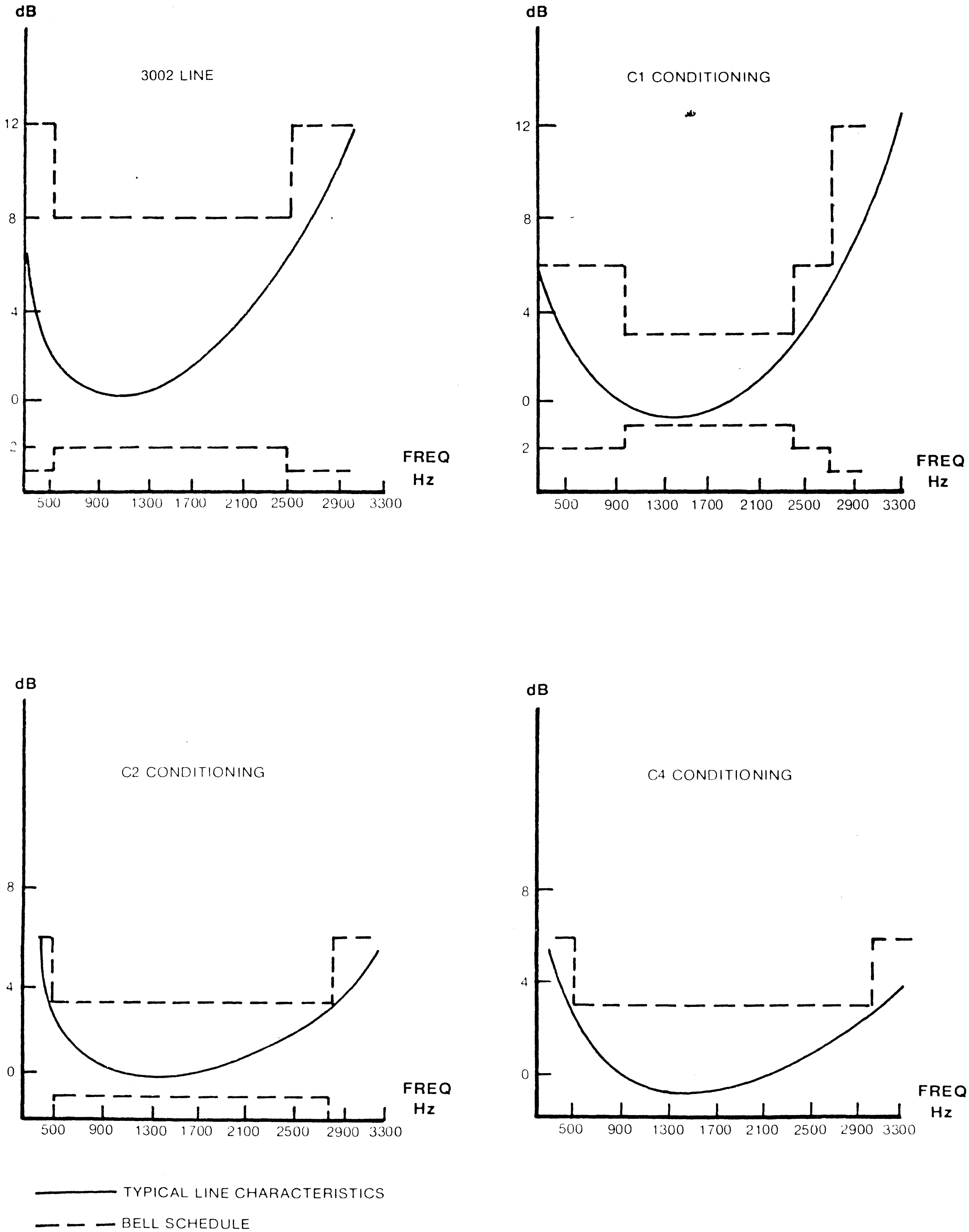
F. Third-point operation describes the conditioning where point A (master) can transmit to B and C (slaves) simultaneously and both B and C can respond to A. Transmissions between B and C are possible, but the characteristics are not specified.

G. C3 conditioning, not included in this table, describes conditioning of access lines and trunks in central office switching applications. An end-to-end connection consisting of four trunks and two access lines with C3 will approximate C2 conditioning overall.

H. The "vb" in the objectives refers to the voiceband filter in the measuring set. This approximates the "C" message filter and the typical response of the voice grade channel.



ENVELOPE DELAY DISTORTION (GROUP DELAY) CHARACTERISTICS



ATTENUATION CHARACTERISTICS

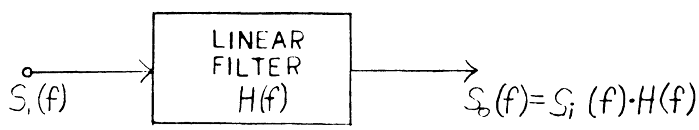
C. Equalization

<u>Equalization</u> - is a technique used to compensate for distortions present on a communication channel. Equalizers add loss or delay to signal in inverse proportion to the channel characteristics. The signal response curve is then relatively "flat" and can be amplified to regain its original form.

- Equalization is usually accomplished with analog or digital filters.

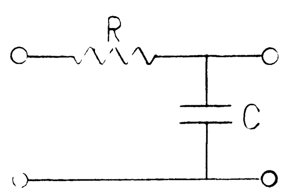
- <u>Filter</u> is electronic circuitry that blocks some signal components while allowing other components to pass through uniformly.

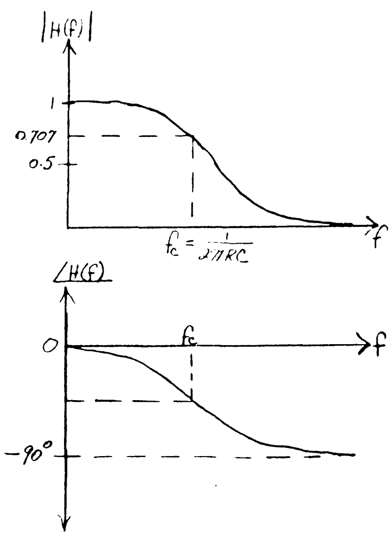
  <u>Filtering</u> corresponds to multiplying the signal spectrum S(F) and the filter frequency response H(F)



Linear Filter H(f)

- Filters may consist of simple passive circuits containing resistors and capacitors.



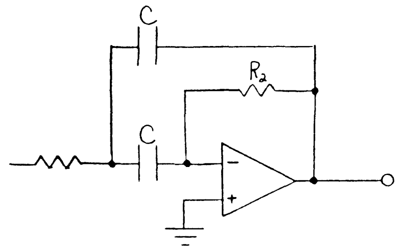


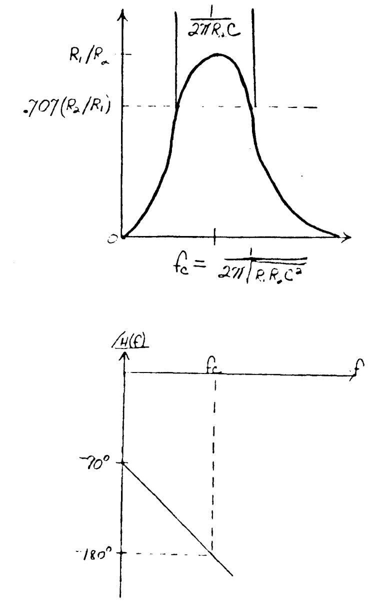
$$H(f) = \frac{1}{1-j2\pi fRC}$$

$$H(f) = \frac{1}{1+j(f/f_c)}$$

Passive First Order Analog Low Pass Filter

- Filters may consist of more complex active circuits that contain operation amplifiers, resistors, and capacitors.

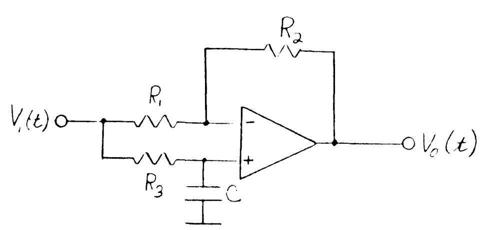


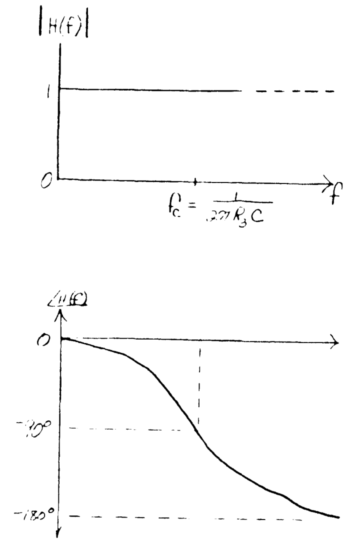


$$H(f)=\frac{\left(\frac{-1}{2}\frac{R_2}{R_1}\right)j2R_1C\omega}{1+j2R_1C\omega-R_1R_2C^2\omega^2}$$

$$\omega=2\pi f$$

Active Second-Order Analog Bandpass Filter



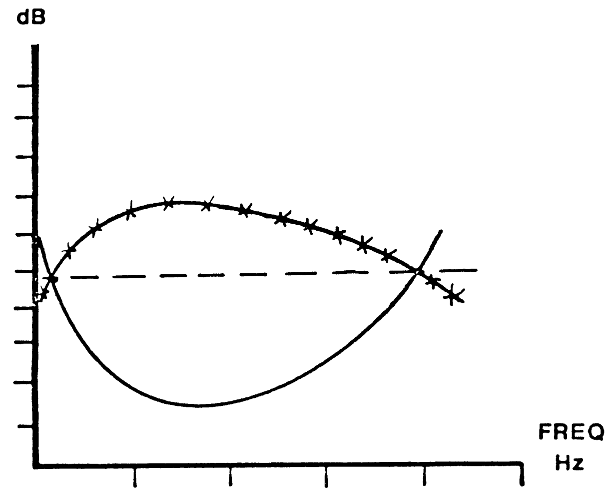


$$H(f)=\frac{1-j\omega R_3C}{1+j\omega R_3C}$$

$$H(f)=\frac{1-j(f/f_c)}{1+j(f/f_c)}$$

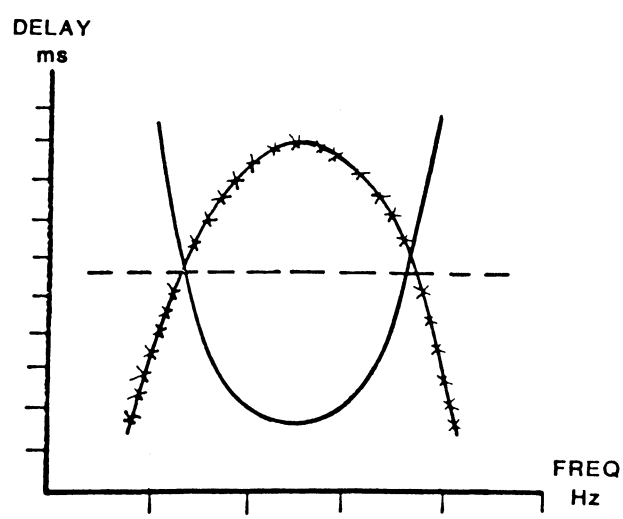
$$\omega=2\pi f$$

Active All Pass Analog First-Order Phase Shift Filters



Ideally Equalizing for Attenuation Distortion

Several stages of filters may be combined to compensate for attenuation distortion on the line by creating a filter response opposite that of the line characteristics. The output of the filter network is a flat attenuation response.



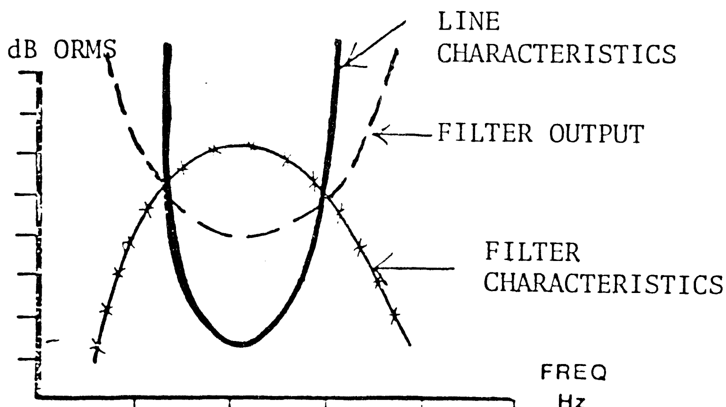
Ideally Equalizing for Envelope Delay
(Group Delay) Distortion

Several stages of filters may be combined to compensate for group delay (phase) distortion on the line by creating a filter response opposite that of the line characteristics. The output of the filter network is a flat group delay response.

Fixed Statistical Compromise Equalizer is an equalizer that is fixed (cannot be changed). It's design is based on the networks statistics. The shape of the equalization is a compromise between the worse case line condition and a "back to back" line condition. This type of equalization is only practical on modems operating at less than 1200 bps.

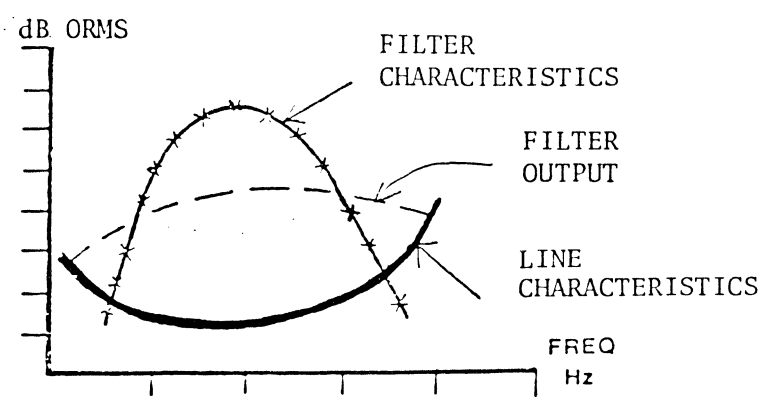
The attenuatioon distortion and group delay distortion characteristics of the telephone line vary greatly from one line to the next.

- It is therefore very difficult to design a compromise value of equalization that will permit satisfactory operation on all telephone lines.



Under Equalization

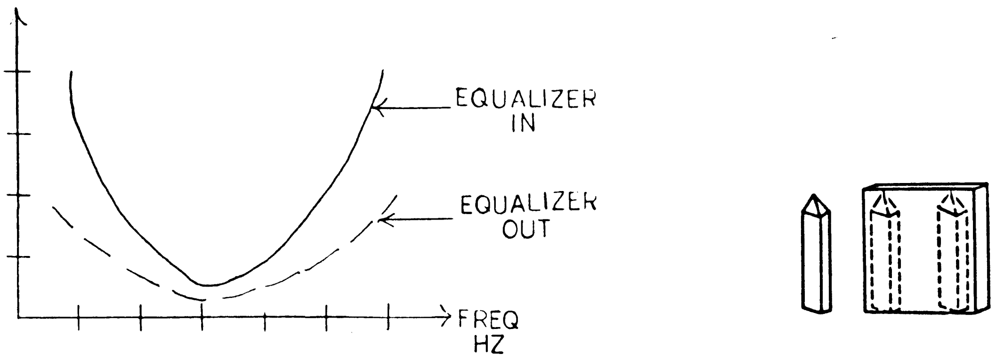
If the filter characteristics are not sufficient to compensate for the line characteristics, the output of the filter will not have a flat response. Therefore, the signal will still be distorted.



Over Equalization

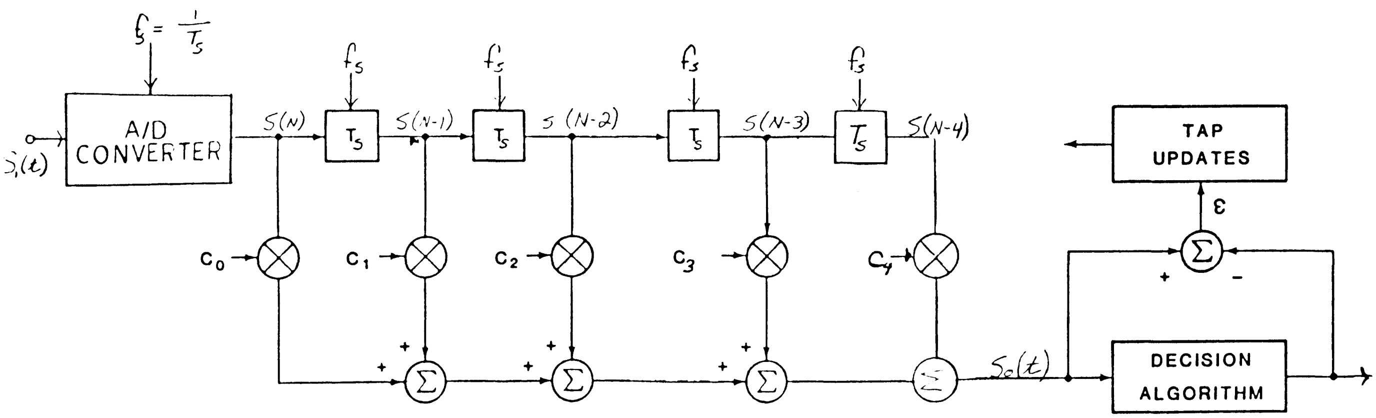
If the filter characteristics over compensate for the line characteristics, the output of the filter will not have a flat response. Therefore, the signal will still be distorted.

- Manually Adjustable Equalizers are used to help compensate for these variations in the line characteristics. Equalization may be selected in or out by a strap or switch option.



Manually Adjustable Equalizer

- On higher speed modems, the equalization becomes more critical. In fact, it is necessary to continually compensate for change line conditions. This is normally accomplished with an Automatic Adaptive Equalizer. The most common Automatic Adaptive Equalizer is the Transversal Digital Filter (tapped delay line).

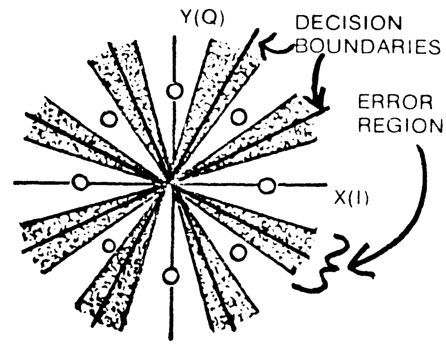


$S_o(N) = \sum_{k=0}^{4} C_k S(N-k)$ = SIGNAL OUTPUT SPECTRUM

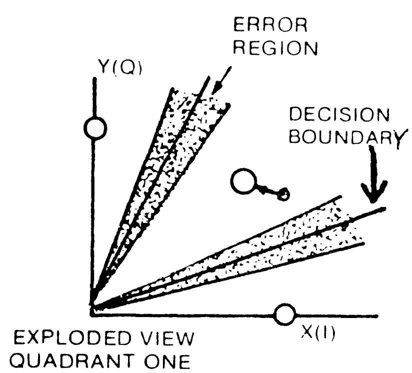
$H(f) = \sum_{k=0}^{4} C_k e^{-j2\pi k T_s}$ = FILTER FREQ RESPONSE

Transversal Digital filter (Tapped Delay Line)

The Automatic Adaptive Equalizer is normally adjusted each baud time. If the actual received baud location in the constellation is within the decision boundaries, the demodulator will use the ideal location for the reference point of the next baud group. The equalizer uses the actual baud location to adjust itself for the intersymbol interference caused by impairments on the line. If the actual received location is in high error region, the baud group may be in error.



Constellatin of 8-Phase DCPSK Modem



Effect of Automatic Adaptive Equalization on Constellation of 8-Phase DCPSK Modem

D. Performance Testing

- Since not all modems were designed to equally compensate for the line characteristics, it is very important to consider the performance of a modem over a variety of line characteristics.

- The modem should be designed to handle very good and very bad line characteristics.

- A modem that operates very poorly (high error rate) on a line with bad characteristics may initially cost less. But, in the long run, it may cause substantially more in time lost for retransmissions, especially if the modem is used over long distance lines. It doesn't take very many retransmissions of data over a long distance telephone call to make up the difference between a cheap modem (higher error rate) and a more expensive modem (lower error rate). The slightly more expensive modem will, in most cases, better compensate for the line impairments. But, don't look at cost only. The best way to verify the performance over varied line conditions is to use a telephone line simulator and a bit error rate tester.

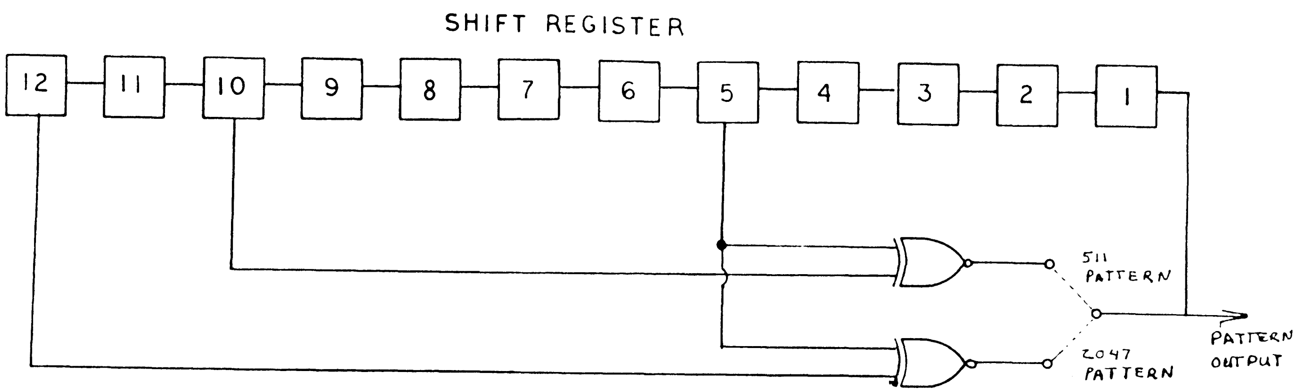
- Opinions vary greatly as to what values should be used for the impairments when conducting performance tests. In general, tests should be performed over several shapes of amplitude distortion and envelope delay distortion (back to back, typical line and worse case line). The modem should be tested in the presence of harmonic distortion, frequency translation, and phase jitter. Common values of harmonic distortion, frequency translation, and phase jitter can be found in ATT published Survey Reports. Test results are normally expressed in terms of Probability of Bit Error Rate versus Signal to Noise Ratio. This curve is plotted by recording the number of errors received in a large number of bits received (i.e. five errors in one million bits) at varied signal to noise ratios. The modem is normally tested at receive signal levels of -20dBm and -30dBm.

- CCITT V.56 specifies a block diagram of a telephone line simulator. The basic block diagram for the simulator is valid for the Continental United States, but, the values specified for amplitude distortion and envelope delay distortion are considerably different from those experienced in the United States. If a modem was designed to perform well on these lines it would perform very poorly on actual telephone lines in the United States.

- Several manufacturers make telephone line simulators that may be used for modem performance testing.

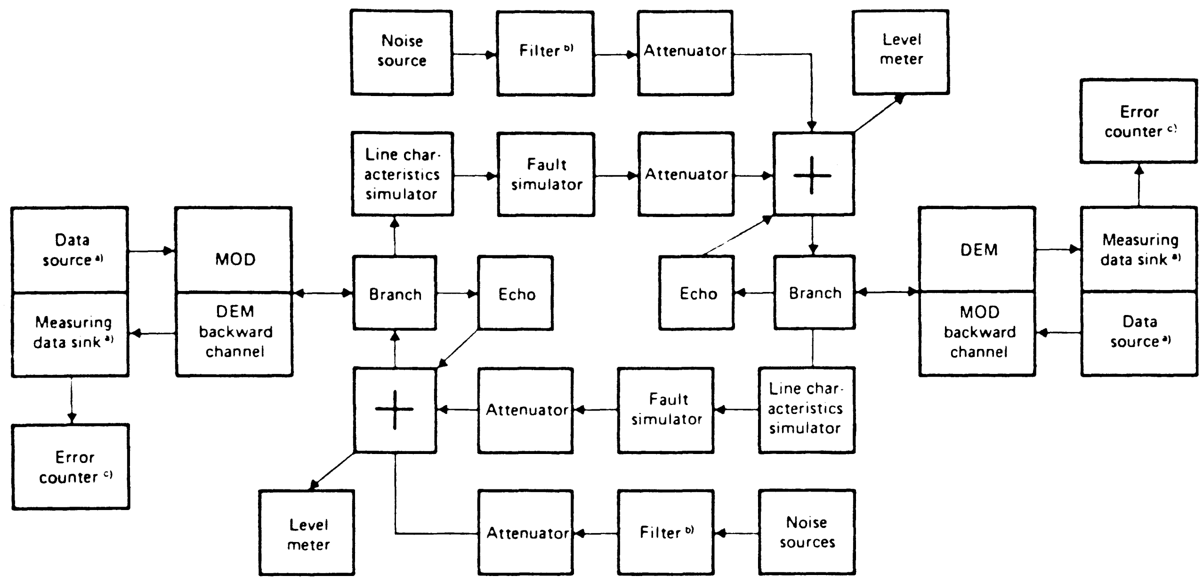
- A Bit Error Rate Tester (BERT) is normally used to generate pseudo-random data patterns and check for errors in the data patterns.

  - common Pseudo-Random Data Patterns are 2047, 511, and 63 bits in length before starting over.

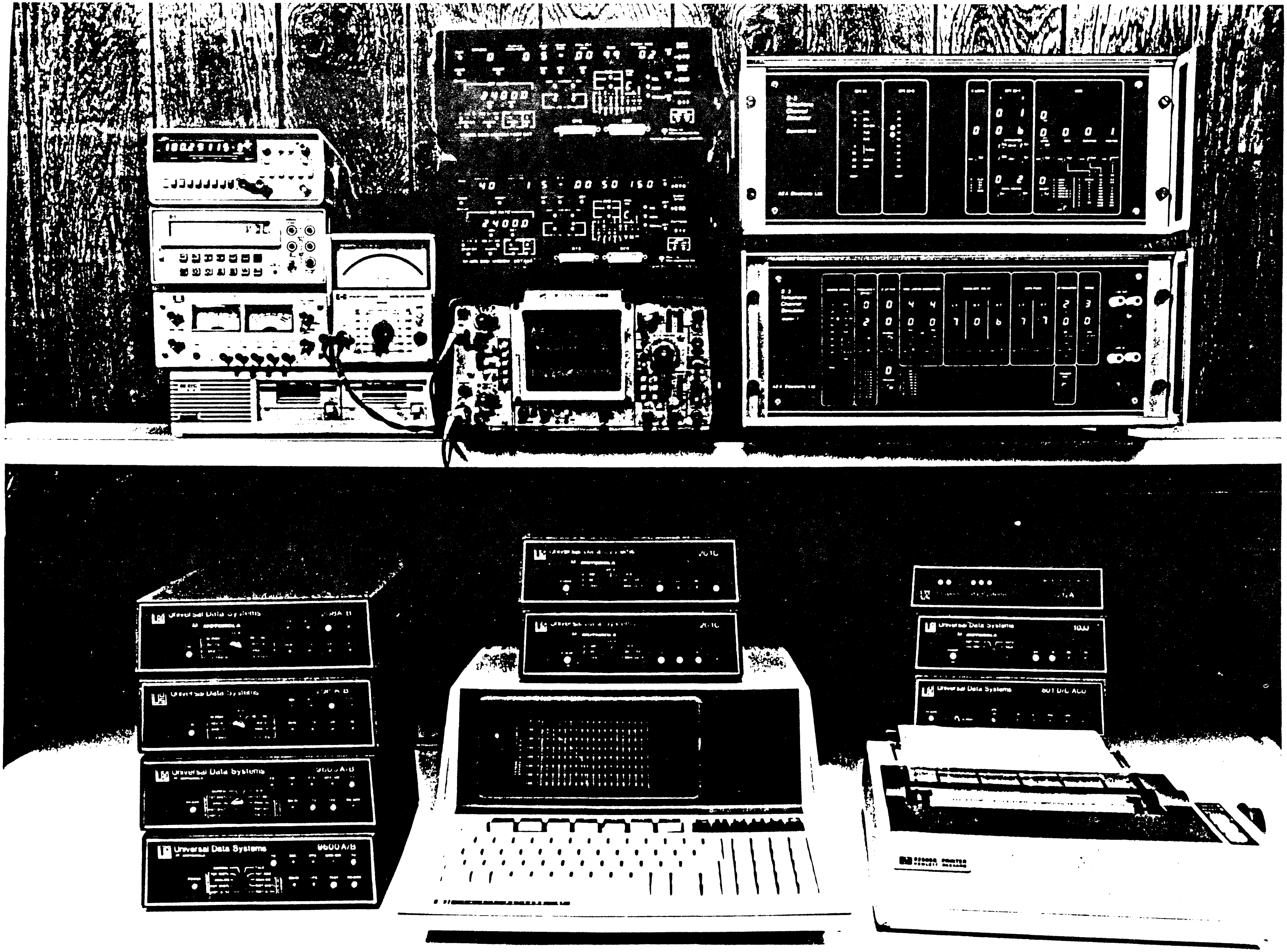


CCITT 511 **Psuedo-Random Data Patterns Generator**

- other common patterns are Mark (all "1's"), Space (all "0's"), Alternate (alternately "1's" and "0's") and Quick Brown Fox (The Quick Brown Fox Jumps Over the Lazy Dog 0123456789).



CCITT V.56 - Block Diagram of a Telephone Line Simulator

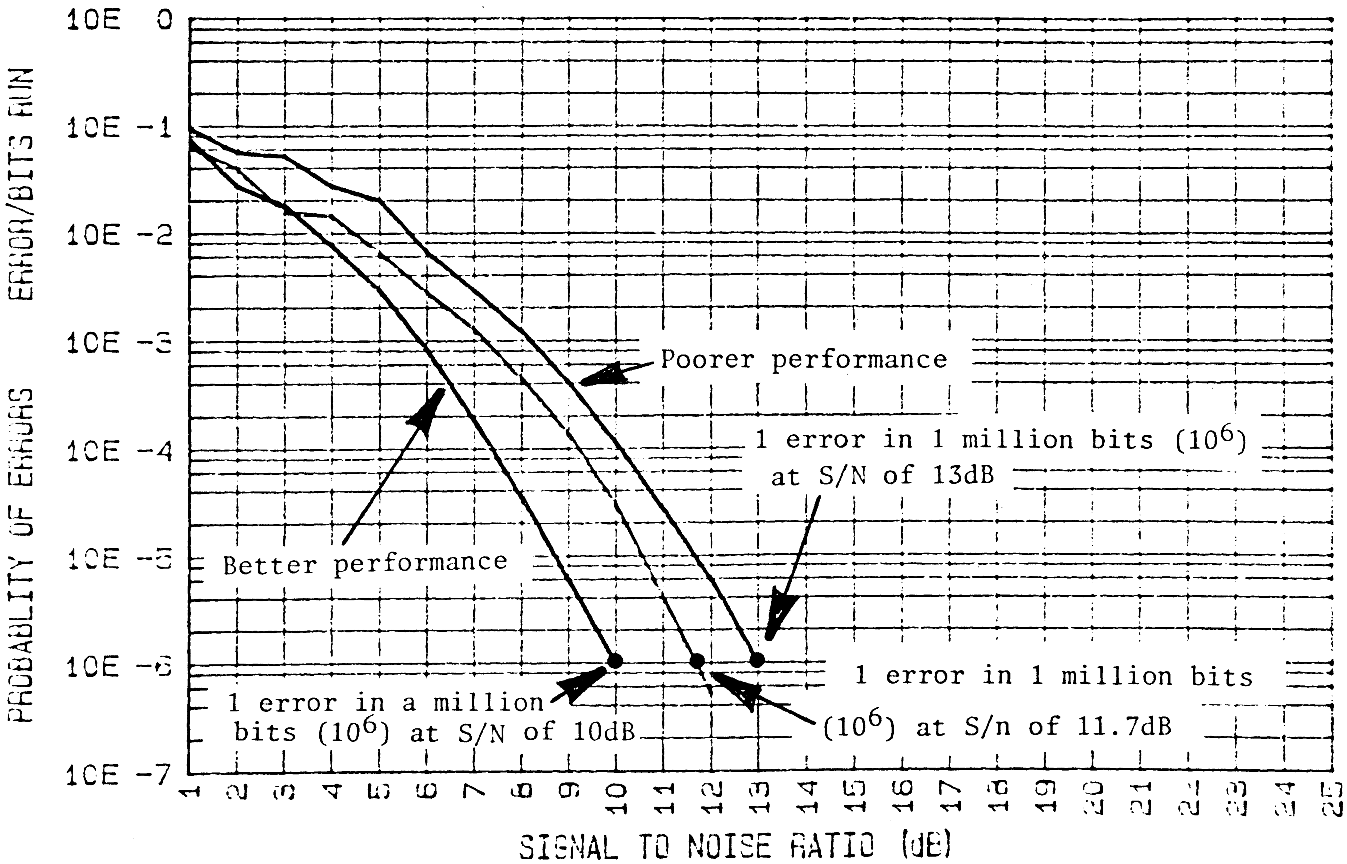


AEA Automatic Telephone Line Channel Simulator

- Signal to Noise Ratio (S/N) - the relative power levels of a signal and noise on a communications line, expressed in decibels.

$$(S/N)dB = SdBm - NdBm$$

- Signal to noise ratio performance curve - curve showing probability of bit errors or message errors vs signal to noise ratio.



Signal to Noise Ratio-Performance Curve

8. Communications Interface Units (CIU) and Data Circuit-Terminating Equipment DCE

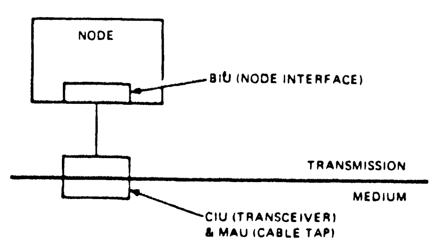
(A) Communications Interface Unit (CIU) - the LAN component that logically interfaces to the network. It changes signals from the node interface into the form and format appropriate for transmission over the medium.

- digital to analog and analog to digital
- parallel to serial and serial to parallel
- drives message over the medium
- provides power and ground isolation
- povides error detection at the physical and data link levels
- in distributed control, it monitors the network channel for message traffic to determine if it can transmit the message of its node

(1) Transceivers - communication interface unit (CIU) used in baseband LAN's

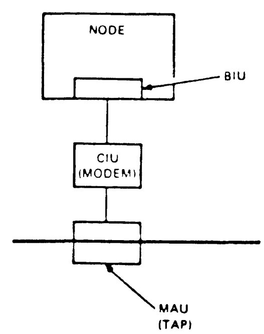
Media Access Units (MAU) - device used to physically connect to medium (i.e., cable tap)

Bus Interface Unit (BIU) - interface between the nodes internal bus (or equivalent electrical circuitry) and the CIU.



Transceiver, Media Access Unit and Bus Interface Units

(2) Modems - CIU used in broadband LAN's, MAN's, and PBX's. The bus interface unit (BIU) used with a modem normally conforms to RS232-C, RS449/422/423, CCITT, V.24/V.28. It may all be a programmed or interrupt-driven I/O interface. Lower speed modems normally operate in the voice frequency range (less than 20K Hz). Very high speed modems normally operate in the radio frequency (RF)range (less than 400 MHz).

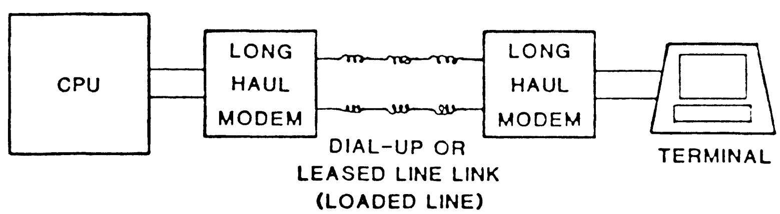


Modems, Bus Interface Units, and Media Access Units

B. Data Circuit-Terminating Euipment (DCE) - previously called data communications equipment. Equipment (such as a modem) installed at a users premises that provides all the functions required to establish, maintain and terminate a connection and signal conversion and coding between the data-terminal equipment and the common carrier's line.

(1) Long Haul Modem

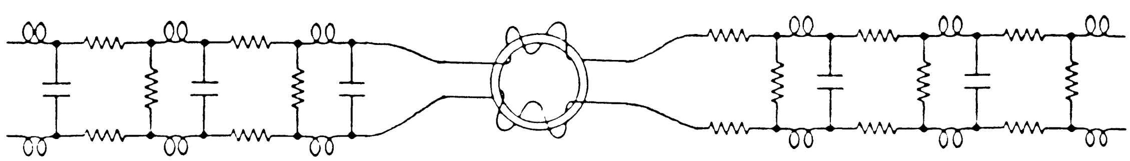
- Modem used over long distances via the dial up network or leased line (3002).
- Will operate with lines using loading coils.
- Use carrier modulation type of signaling.

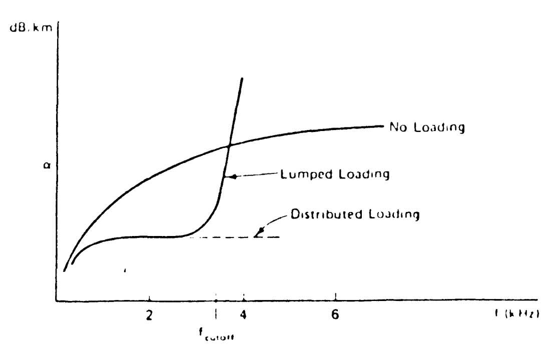


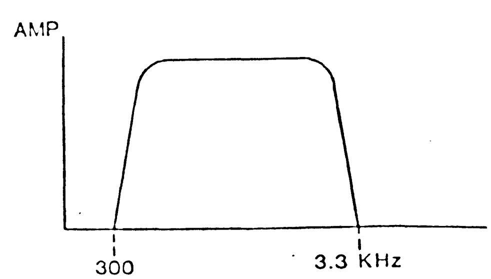
Long Haul Modems

Loading Coil - a helically wrapped core placed on the telephone line every 1.6 km for the purpose of reducing attenuation and phase distortion within a given band. This is accomplished by cancelling the distributed capacitance on the telephone line.

Loading Coil Winding







FREQUENCY RESPONSE OF LOADED LINE

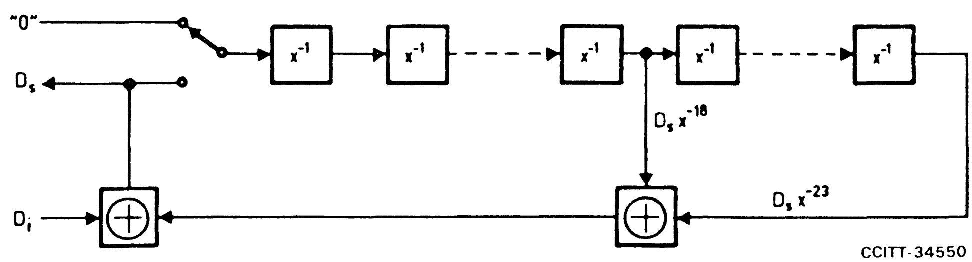
Loading Coil, Loaded Line and Bandwidth of a Loaded Line

(2) Basic Elements of a Long-Haul Modem

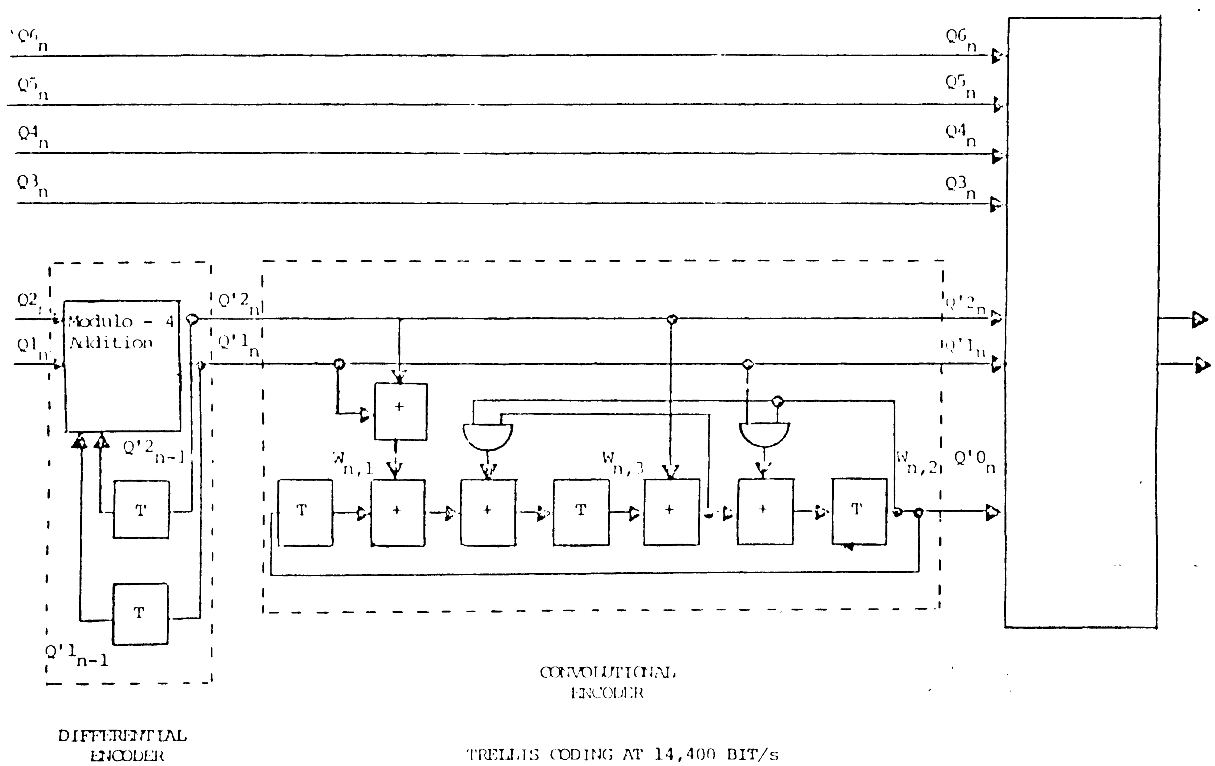
- Transmitter or modulator converts digital data originating from a terminal computer or other source into audio signals suitable for transmission over a communication facility.

  Data Encoder portion of the modem is part of the transmitter. It is used in conjunction with the transmitter timing to determine what modulation changes are to be made to the carrier frequency at each sampling instant. In the 201B modem, the data encoder would group the incoming binary data into dibit pairs and then determine one of four phase shifts for the carrier.

$$D_s = D_i + D_s x^{-18} + D_s x^{-23}$$



Data Scrambler



TRELLIS CODING AT 14,400 BIT/s

Transmitter Control - controls turning on of modems carrier and RTS to CTS delay.

Transmit Timing Source - outputs transmit clock (TC). Phase locks TC to external transmit clock (ETC) when strapped for external transmit clock. Used on synchronous modems.

Test Generator - generates 511 peudo random data pattern when in test mode.

Modulator part of the transmitter is used to change the carrier frequency as determined by the Data Encoder. The type of change imparted depends on the type of modulation desired for transmission.

Band Limiting Filter - the primary purpose of the transmitter band limiting filter is to shape the frequency spectrum of the analog signals generated by the modem. It is advisable to bandlimit the analog signal before it is transmitted. This is important because even though the telephone line is a bandpass filter itself, one cannot count on it characteristics since they change with time. If the bandwidth of the transmitted spectrum can be contained within the usable characteristics of the telephone line, more reliable data transmissions will result.

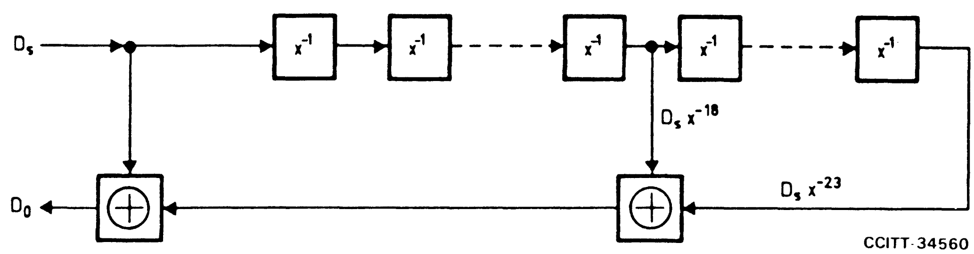
Line Amplifier - a variable gain amplifier. It is usually manually adjustable in 2dB steps. It may also be adjusted via the Program Resistor (PR) and Programcommon (PC) leads. The telephone company installs a programming resistor in the RJ45S or RJ41S across the PR and PC leads. The programming is adjusted to provide a -12dBm signal level at the Central Office.

Transformer - provides connection between the modem and the medium. It is also used to provide DC isolation and impedence matching. The transmit transformer is used for both the transmit and received signals when set up for two wire operation.

- Receiver or Demodulator - accepts audio signals from the communications facility, converts them back to their original digital format, and presents this data signal to the appropriate terminal computer or data sink.

  Data Decoder is part ofthe receiver that is used in conjunction with the demodulator to format the received data into a serial binary pattern to be shifted out of the modem to the terminal. In the 201B, this circuit element converts the differential phase shifts to dibit pairs, then to single bits, before making them available for external use.

$$D_0 = D_1 = D_S(1 + x^{-18} + x^{-23})$$



Data Descrambler

Clock and Phasing Circuits - derives receive clock from demodulated signal to be output on RS232 interface. Used on synchronous modems.

Pattern Checker - checks received 511 pseudo ramdom data pattern for error when in test mode. Outputs LED indication when errors are received.

Demodulator is the part of the receiver that extracts the baseband (intelligence) information from the composite modulated signal as it is received from the telephone line. In the 201B, this would be the hardware that performs the phase comparison from one sample period to the other in order to determine the differential phase shift that was received.

Equalizer - the equalizer is a network whose amplitude and phase characteristics are the inverse of those presented by the telephone line. The equalizer compensates for channel distortion thereby permitting higher data rates and/or better modem performance. The equalizer is required for modem 2400 bps and higher.

AGC Amplifier - provides Automatic Gain Control (AGC) enabling the modem to compensate for amplitude variations on the line. This amplifier also appears as a limiting stage in digitally implemented modems.

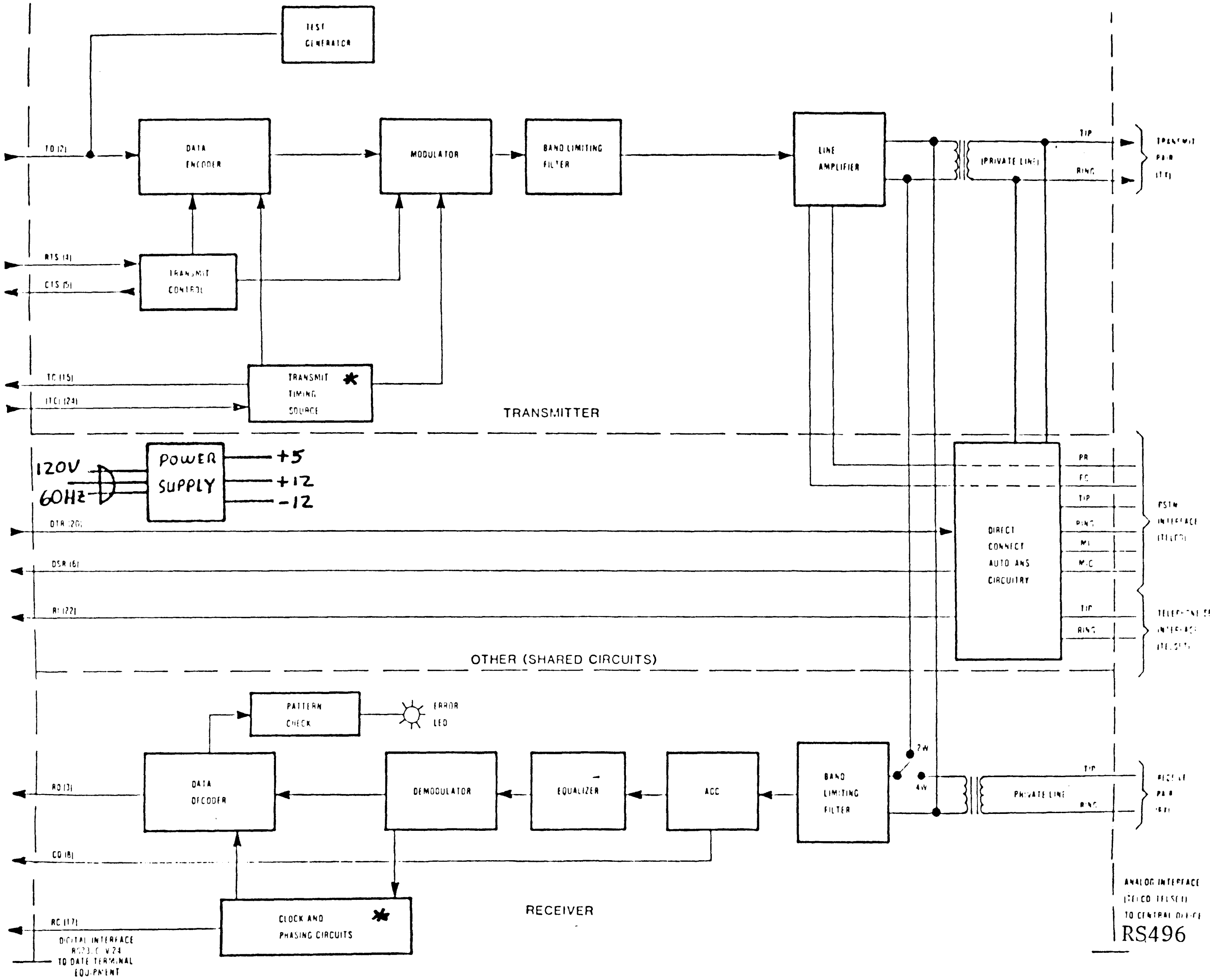
Band Limiting Filter - the primary purpose of the receive band limiting filter is to shape the frequency spectrum of the analog signal received from the communications line. This filter eliminates any extraneous frequencies (such as noise) that are outside of the frequency band containing intelligence.

Transformer - provides connection between the medium and the modem. It also provides DC isolation and impedence matching. The separate receive transformer is used when set up for 4-wire operation.

- Other (Shared Circuits)

Power supply - provides DC power for the modem. Converts 120V AC 60Hz to +5V, +12 and -12V.

Direct Connect Auto Answer Circuitry - Data Access Arrangement (DAA) portion of modem. Provides Telephone Company Central (CO) protection and auto answer circuitry. Permits connections of modem or telephone line. This section is FCC Part 68 Registered for direct connection to the Public Switched Telephone Network (PSTN).



* Synchronous Modem Only

Basic Elements of a Modem

(3) Standard "Bell" and Consultative Committee for International Telephone and Telegraph (CCITT) Modems

(A) Definitions

Synchronous modem - uses a clock to perform bit synchronization of incoming and outgoing data.

Asynchronous modem - does not use a clock to perform bit synchronization of incoming and outgoing data.

FSK - Frequency Shift Keyed

DCPSK - Differentially Coherent Phase Shift Keyed.

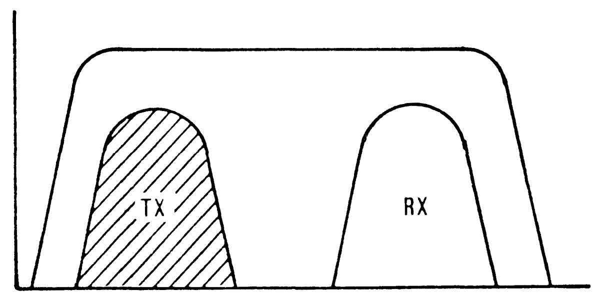
QAM - Quadrature Amplitude Modulation

Secondary Channel (reverse or backward channel) - an optional feature on some modems that provides simultaneous communication from the receiver to the transmitter on a 2-wire channel. This channel is normally at a slower speed than the primary channel. It is used for message transmission, circuit assurance or breaking, and to facilitate certain forms of error control and network diagnostics. Also, it may be used to send data that is being typed (slow rate) in one direction and sending screen of information (fast rate) in the other direction.

PL - Private Line

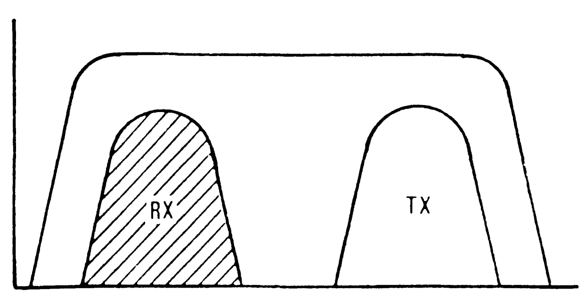
Dial - dial up line, Public Switched Telephone Network (PSTN)

Originate Mode - a term used with full duplex Frequency Division Multiplexing modems that describes what bands are used for transmission and reception. A modem that is in the originate mode transmits in the lower frequency band and receives in the higher frequency band. The modem that originates the call normally configures itself for this mode. On some modems originate or answer modes may be selected with a switch.



Modem in Originate Mode

Answer Mode - a term used with full duplex Frequency Division Multiplexing modems that describes what bands are used for transmission and reception. A modem that is in the answer mode transmits in the higher frequency band and receives in the lower frequency band. The modem that answers the call normally configures itself for this mode. Some modems may be selected for originate or answer modes using a switch.

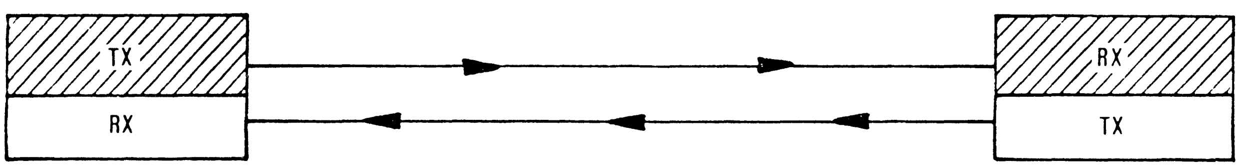


Modem in Answer Mode

- The term originate mode should not be confused with Automatic Call Origination (ability to automatically place a call) or a Simplex Mode of Operation (where one device transmits only and the other device receives only).

- The term Answer Mode should not be confused with Automatic Answer (ability to automatically answer calls) or a Simplex Mode Operation (where one device only receives and the other device only transmits).

- All that is important when considering Originate and Answer modes is that the modem on one end is in Originate mode and the modem at the other end is in Answer mode.



Modem is in Originate Mode, the Other Modem is in Answer Mode

- Two modems in answer mode will not communicate with each other.

- Two modems in originate mode will not communicate with each other.

- A 103J modem, upon automatically answering a call, will be in the answer mode. Thus, the originator of the call must be in the originate mode.

- A 212A or V.22 Bis (2424) will automatically configure itself in the opposite mode of the call originate mode upon automatically answering a call. Thus, the originator of the call may be in originate or answer mode.

TYPES OF MODEMS

Data Rate	CCITT "Family"	Bell "Family"	Sync (CLK)	Async (No CLK)	Type Modulation	Full Duplex	Half Duplex	Secondary Channel	PL	Dial	Baud Rate
0 to 300 bps	V.21	103 Series		X	FSK	2-Wire			X	X	0 to 300
0 to 1200 bps (1800 bps)	V.23	202 Series		X	FSK	4-Wire	2-Wire	X	X	X	0 to 1200 (1800)
0 to 300 bps		212A		X	FSK	2-Wire			X	X	0 to 300
1200 bps	V.22	212A	X	X	DCPSK	2-Wire			X	X	600
1200/600 bps	V.22		X	X	DCPSK	2-Wire			X	X	600
2400/1200 bps	V.22 BIS	224	X	X	QAM	2-Wire			X	X	600
2400 bps	V.26	201B	X		DCPSK	4-Wire	2-Wire	X	X		1200
2400 bps		201C	X		DCPSK		2-Wire	X		X	1200
2400/1200 bps	V.26 BIS		X		DCPSK		2-Wire	X		X	1200
2400/1200 bps	V.26 TER		X	X	DCPSK	2-Wire		X		X	1200
4800 bps	V.27	208A	X		DCPSK	4-Wire	2-Wire	X	X		1600
4800/2400 bps	V.27 BIS		X		DCPSK	4-Wire		X	X		1600
4800 bps	V.27 TER	208B	X		DCPSK	4-Wire	2-Wire	X		X	1600
9600 bps	V.29	209	X		QAM	4-Wire	2-Wire	X	X		2400
7200 bps	V.29		X		QAM	4-Wire	2-Wire	X	X		2400
4800 bps	V.29		X		QAM	4-Wire	2-Wire	X	X		2400
9600 bps	V.29	9600A/B	X		QAM	4-Wire	2-Wire		X	X	2400
9600	V.32		X	X	QAM-Trellis	2-Wire		X	X	X	2400
4800			X	X	QAM-Trellis	2-Wire		X	X		2400
14400 bps	V.33		X		QAM-Trellis	4-Wire		X	X		2400
12K bps	V.33		X		QAM-Trellis	4-Wire		X	X		2400

Note: This Table presents similarities between Bell and CCITT Modems. In most cases the two families are not compatible.

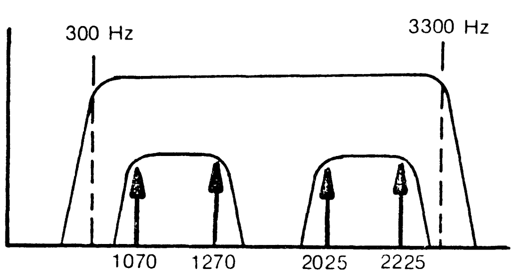
Standard Types of "Bell" and CCITT Long Haul Modems

Select a Modem

- 0 bps
  - 1. Full Duplex 2. 2 Wire PSTN 3. Originate/Answer 4. Async
    - 1. AC Power 2. Auto Answer → **103 J**
    - 1. Telephone Line Power
      - 1. Manual Answer/Originate → **103 0/A LP**
      - 1. Auto Answer → **103 J LP**
  - 1. Full Duplex 2. Private/Leased Line 3. Originate/Answer 4. Async → **108**
- 00 bps
  - 1. Full Duplex-2 Wire PSTN 2. Full Duplex-2 Wire Private/Leased
    - 1. Auto Answer 2. Async 3. Sync
      - 1. Manual Dial → **212A**
      - 1. Auto Dial → **212A/D**
    - 1. Manual Answer/Originate 2. Telephone Line Power 3. Async Only 4. PSTN Only → **212 LP**
  - 1. Half Duplex (2 Wire) PSTN
    - 1. Auto Answer
      - 1. AC Power
        - 1. Sync → **202S/SS**
        - 1. Async → **202S**
      - 1. Telephone Line Power 2. Async → **202 SLP**
    - 1. Manual Answer
      - 1. Telephone Line Power → **202 LP**
      - 1. 5 Baud Reverse Channel → **202S/5**
- 00 bps
  - 1. Half Duplex (2 Wire) Private/Leased Line 2. Full Duplex (4 Wire) Private/Leased Line 3. Multidrop w/ Anti-Streaming 4. C2 Conditioned Lines for 1800 bps → **202T**
- 0 bps
  - 1. Half Duplex (2 Wire) PSTN 2. Sync Only 3. AC Power 4. Auto Answer → **201C**
  - 1. Half Duplex (2 Wire) Private/Leased Line 2. Full Duplex (4 Wire) Private/Leased Line 3. Sync Only 4. AC Power → **201B**
- 0 bps
  - 1. Half Duplex (2 Wire) PSTN 2. Sync Only 3. AC Power 4. Auto Answer → **208A/B**
  - 1. Half Duplex (2 Wire) Private/Leased Line 2. Full Duplex (4 Wire) Private/Leased Line 3. Sync Only 4. AC Power → **208A/B**
- 0 bps
  - 1. PSTN or Private/Leased Line 2. Half Duplex (2 Wire PSTN or Private) 3. Full Duplex (4 Wire Private or Leased) 4. Sync 5. AC Power 6. Auto Answer → **9600 A/B**
  - 1. Private/Leased Line 2. Full Duplex (4 Wire) 3. Sync/AC Power → **9600**

GLOSSARY: Private/Leased Line: That is not dialed, also termed a dedicated line.
Telephone Line: A dial-up line on the Public Phone Network. Also termed PSTN-Public Switched Telephone Network (formerly called DDD).

B. Common types of modems used in the United States

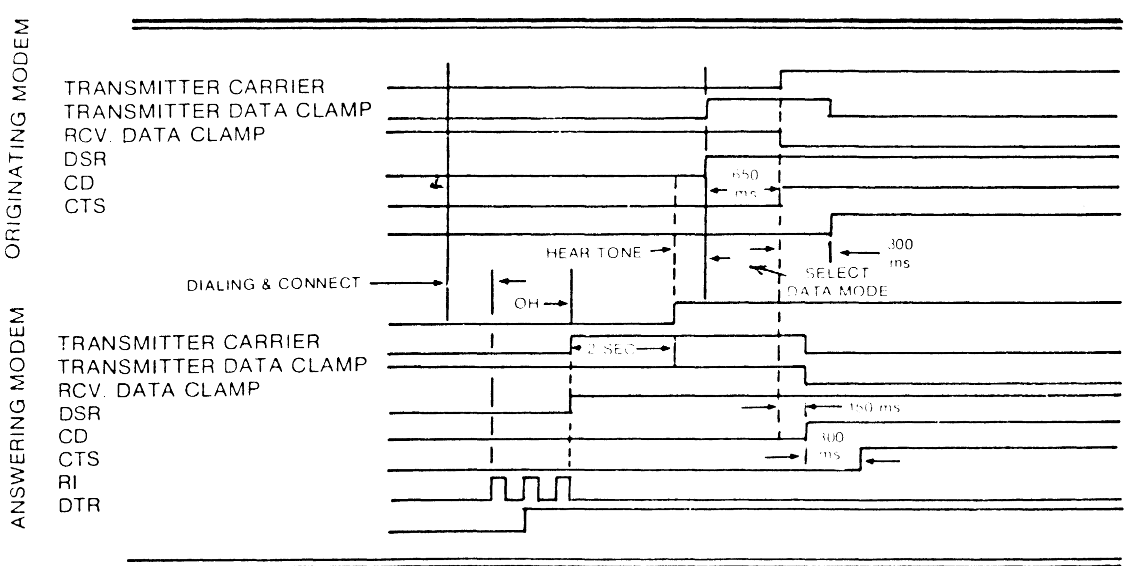


		ORIGINATE	ANSWER	
TRANSMIT	SPACE	1070	SPACE	2025
	MARK	1270	MARK	2225
RECEIVE	SPACE	2025	SPACE	1070
	MARK	2225	MARK	1270

TYPES

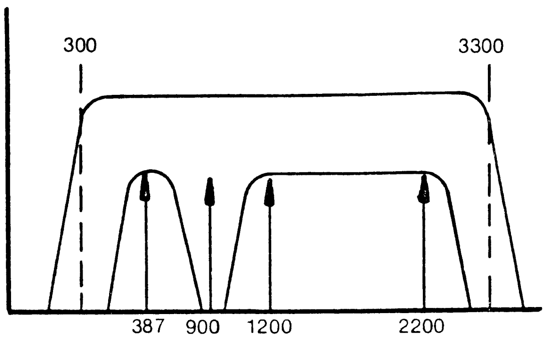
- **103 O/A LP** - 0 TO 300 BPS PSTN; MANUAL ANSWER; LINE POWERED
- **103J LP** 0 TO BPS PSTN; ORIGINATE OR ANSWER AUTOMATIC ANSWER; LINE POWERED
- **103J** —PSTN; ORIGINATE OR ANSWER AUTOMATIC ANSWER
- **113D** - PSTN; ANSWER ONLY AUTOMATIC ANSWER
- **103-1** PRIVATE LINE; ORIGINATE ONLY
- **103-2** PRIVATE LINE; ANSWER ONLY
- **108** PRIVATE LINE ORIGINATE OR ANSWER

103 SERIES SPECTRAL CONTENT AND FREQUENCIES



103J AUTO ANSWER LP HANDSHAKE SEQUENCE

103 SERIES MODEMS
0-300 BPS ASYNCHRONOUS



MARK 1200

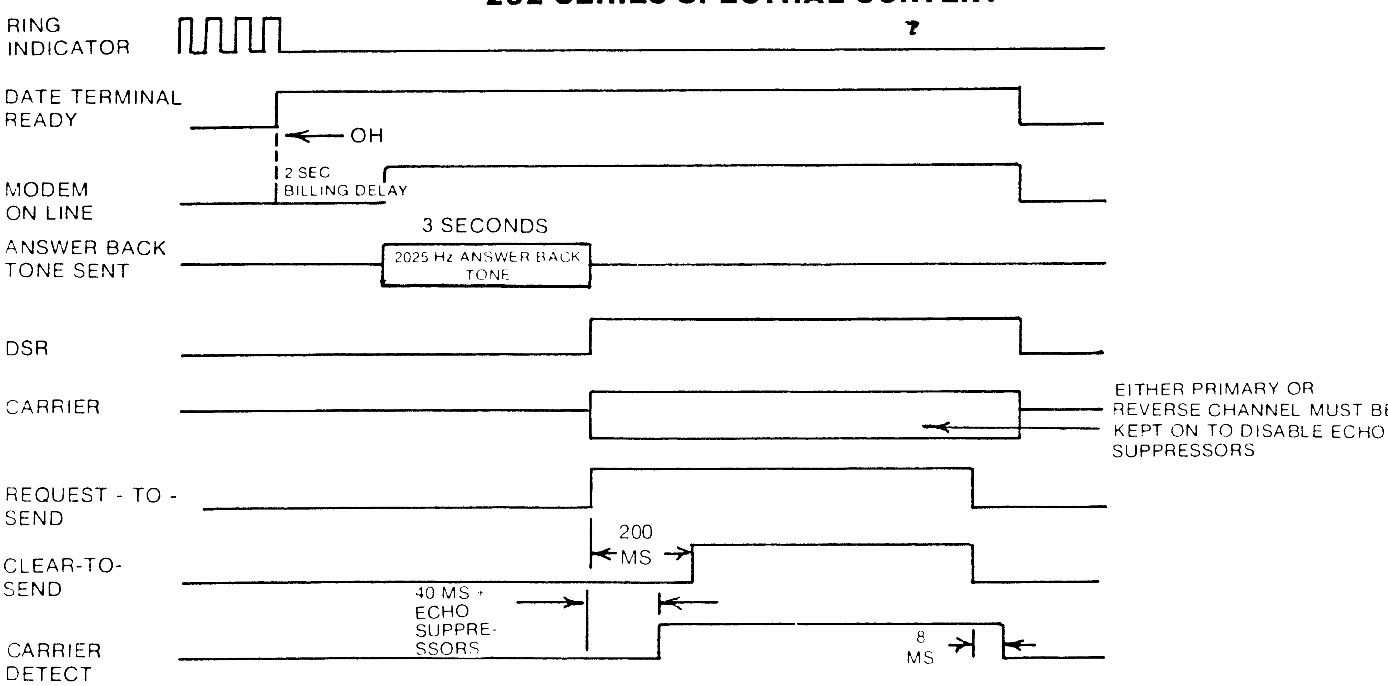
SPACE 2200

SOFT CARRIER TURN OFF 900 Hz (25 ms)

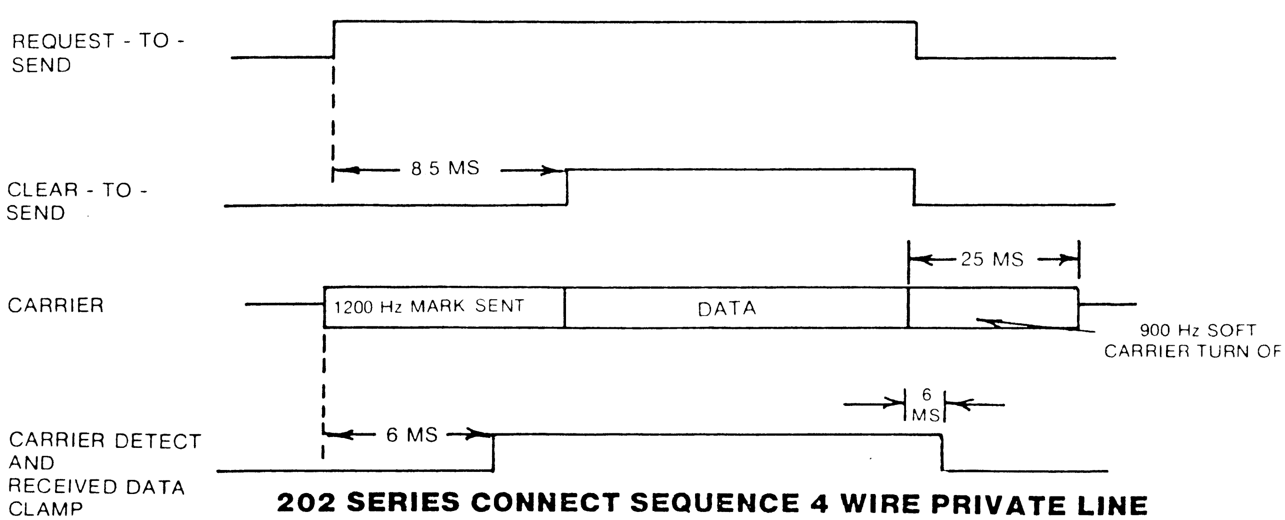
TYPES
- **202S** - 0 TO 1200 BPS PSTN
- **202S/SS** - 0 to 1200 BPS ASYNC 600/1200 BPS SYNC PSTN.
- **202T** - 0 TO 1800 BPS PRIVATE LINE

NOTE:
SUFFIX OF 5,75,150 IS REVERSE CHANNEL SPEED

202 SERIES SPECTRAL CONTENT

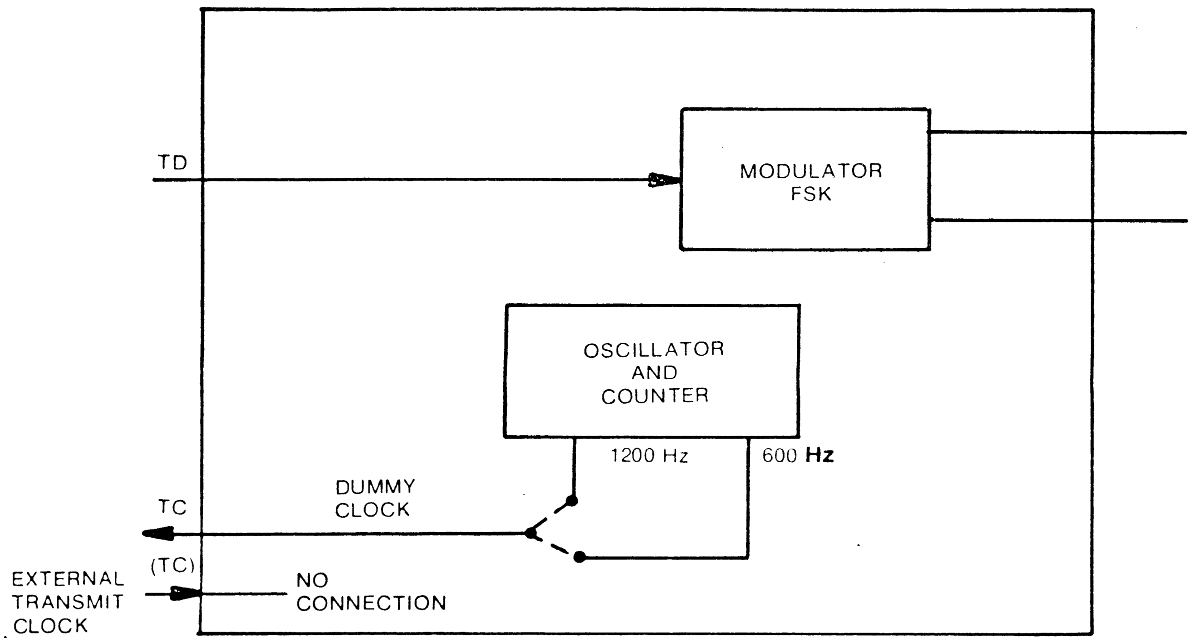


202 SERIES CONNECT SEQUENCE PSTN

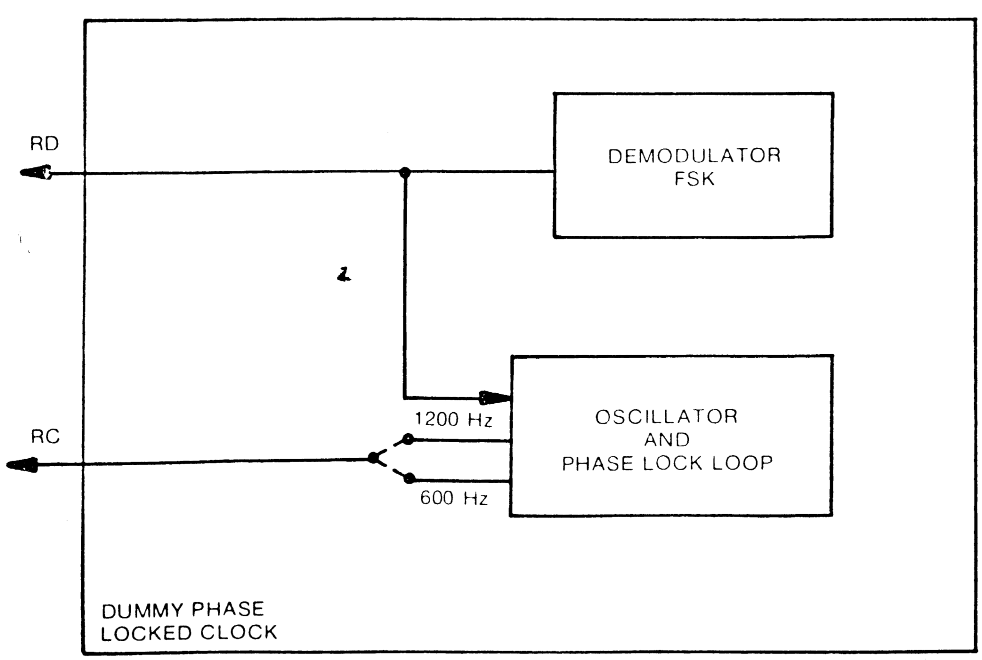


202 SERIES CONNECT SEQUENCE 4 WIRE PRIVATE LINE

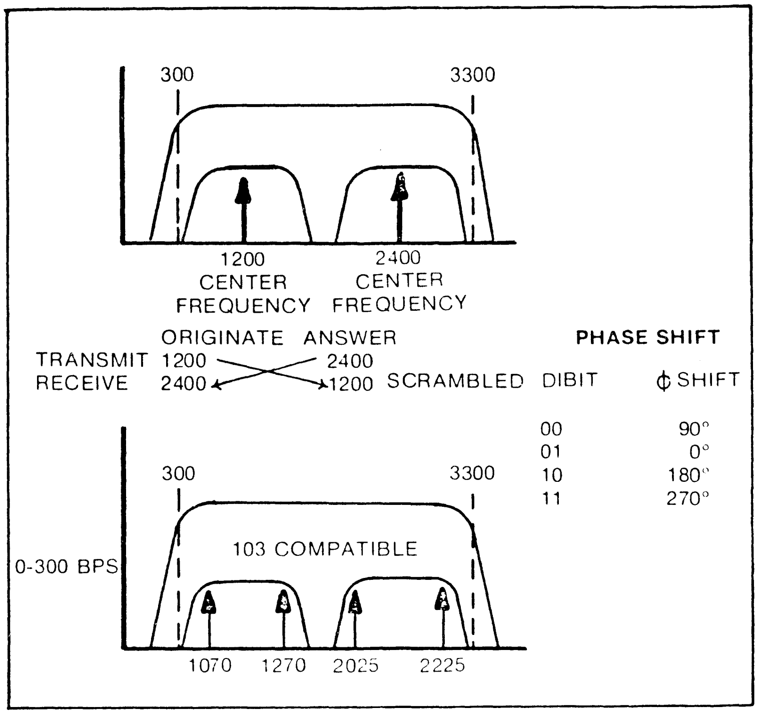
202 SERIES MODEM
0-1200 BPS ASYNCHRONOUS



202S/SS Synchronous Modem Transmitter



202S/SS Synchronous Modem Receiver

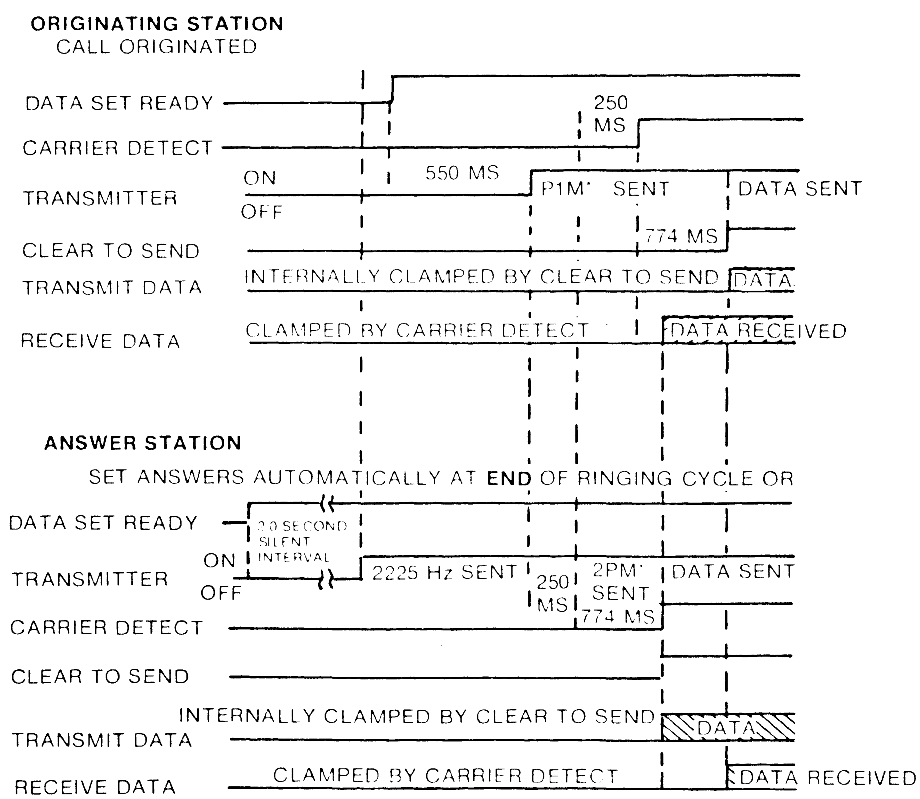


TYPES

- **212A**
  0-300 BPS ASYNC
  FULL DUPLEX
  1200 BPS SYNC OR
  ASYNC. FULL DUPLEX
  AUTOMATIC ANSWER
  PSTN OR PRIVATE LINE
- **212LP** - 1200 BPS
  ASYNC. PSTN.
  LINE POWER MANUAL
  ANSWER
- **212A/D**- 0-300 BPS
  ASYNC FULL DUPLEX
  1200 BPS SYNC OR
  ASYNC FULL DUPLEX
  AUTOMATIC ANSWER
  PSTN OR PRIVATE LINE
  WITH AUTOMATIC DIAL
  CAPABILITY

Data is scrambled

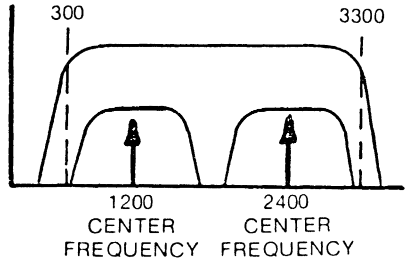
212A SERIES SPECTRAL CONTENT

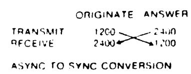


P1M IS THE LOW BAND PHASE SHIFT KEYED SIGNAL REPRESENTING A MARKING DATA SEQUENCE. P2M IS THE SIMILAR SIGNAL IN THE HIGH BAND.

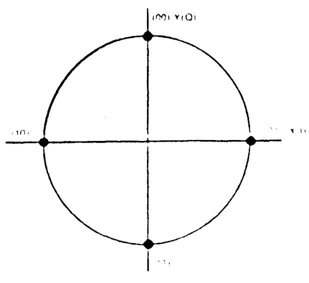
212A HIGH SPEED SERIES CONNECT SEQUENCE PSTN

0-300 BPS, 1200 BPS ASYNCHRONOUS/SYNCHRONOUS HIGH SPEED ONLY

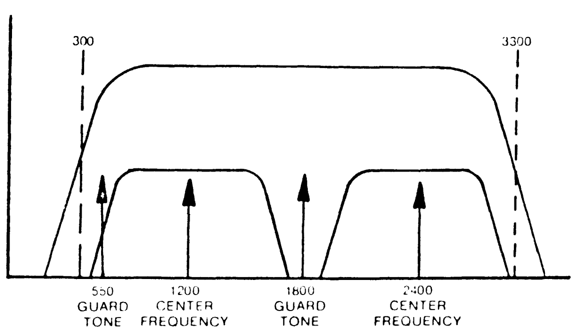




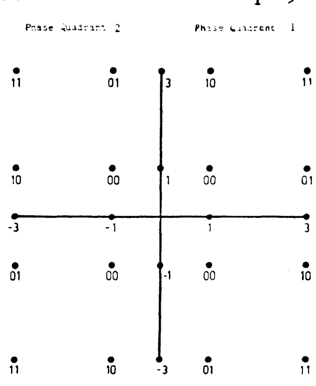
224 (212 - 1200 bps) Spectral Content

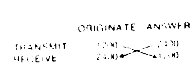


224 (212 - 1200 bps) Constellation



224 (V.22 bis - 2400 bps) Spectral Content





224 (V.22 bis - 2400 bps) Constellation

Dibit	Modulation Phase Shift
00	90^o
01	0^o
10	180^o
11	270^o

Dibit	Modulation Phase Shift
001	0^o
000	45^o
010	90^o
011	135^o
111	180^o
110	225^o
100	270^o
101	315^o

Types

224

2400 bps, full duplex, sync or async, compatible with V.22 bis

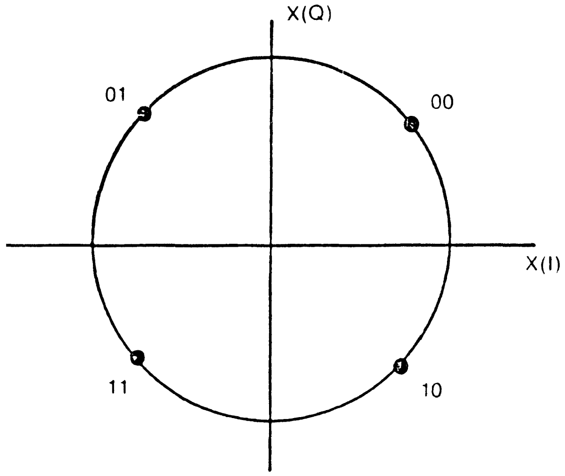
1200 bps, full duplex, sync or async, compatibl(with 212A

May be used on 2 wire private line or PSTN

224 series connect sequence is similar to 212A

Data is scramblec

224 - 2400/1200 bps, Full Duplex, Async or Sync



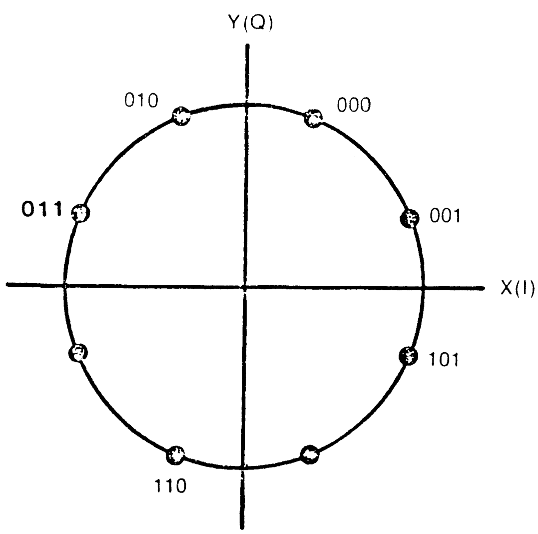
201 Constellation

Modulation Dibit	Phase Shift
00	45°
01	135°
11	225°
10	315°

Types

- 201A - 2000 bps discontinued
- 201B - 2400 bps, 2 or 4 wire private line, sync, half duplex
- 201C - 2400 bps, PSTN automatic answer, sync, half duplex
- 201 series connect sequence is similar to 202 series modem

201 Series Modem - 2400 bps Synchronous



208 Constellation

MODULATION

TRIBIT	PHASE SHIFT
001	0°
000	45°
010	90°
011	135°
111	180°
110	225°
100	270°
101	315°

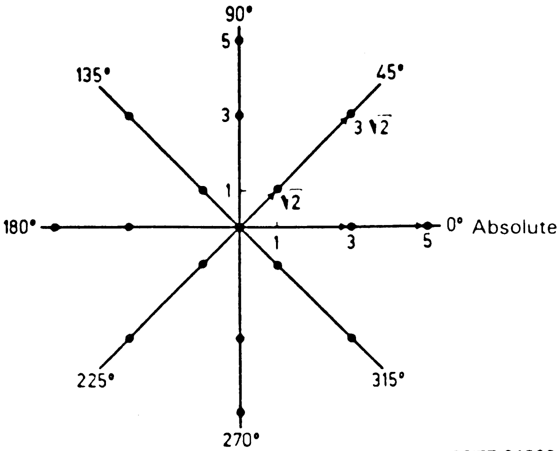
+ 22.5° OFFSET

Types

- 208A - 4 wire leased line 4800 bps, sync.
- 208B - PSTN, 4800 bps 2 wire, sync. Auto. Answer
- 208 series connect sequence is similar to 202 series modems.

Data is gray encoded and scrambled

208 Series Modem - 4800 bps Synchronous



Signal space diagram at 9600 bit/s

Type

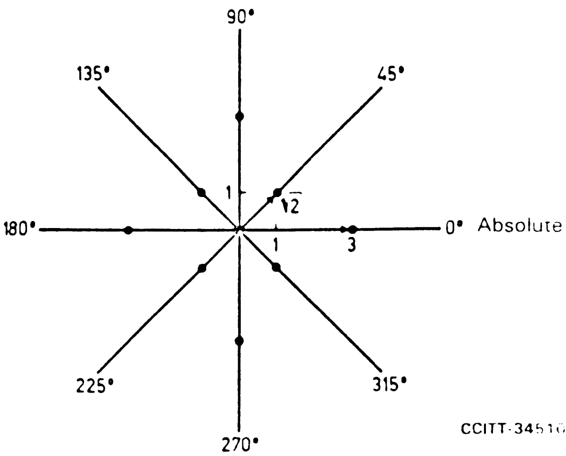
209 - 9600 bps, sync, only made by Bell, not compatible with V.29

9600A - 9600 bps - sync, V.29, private line

9600A/B- 9600 bps - sync, V.29, PSTN, Automatic Answer

9600FP - 9600 bps - sync, V.29 Private line, Fast pole

Data is scrambled and gray encoded



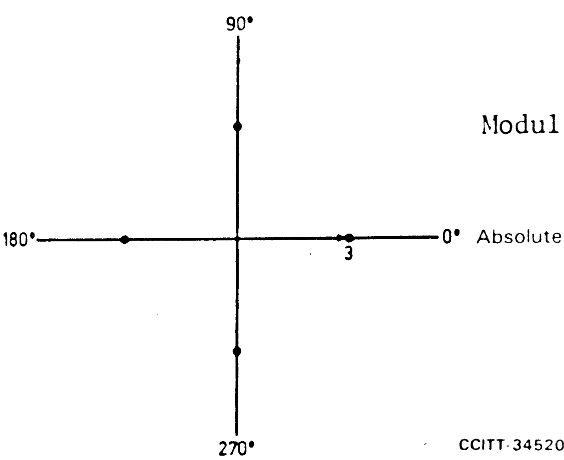
Signal space diagram at 7200 bit/s

V.29 Modulation

QUADBITS Q2	Q3	Q4	PHASE CHANGE
0	0	1	0°
0	0	0	45°
0	1	0	90°
0	1	1	135°
1	1	1	180°
1	1	0	225°
1	0	0	270°
1	0	1	315°

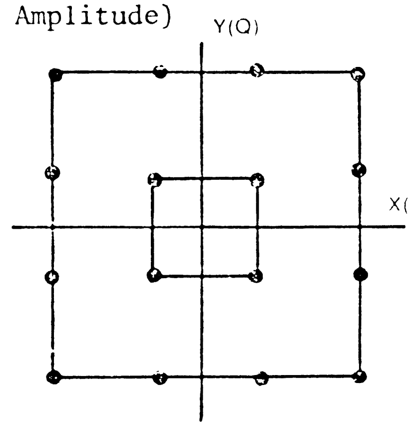
Q1	ABSOLUTE PHASE	RELATIVE SIGNAL ELEMENT AMPLITUDE
0 1	0°, 90°, 180°, 270°	3 5
0 1	45°, 135°, 225°, 315°	$\sqrt{2}$ $3\sqrt{2}$

Modulation QAM (DC PSK and Amplitude)



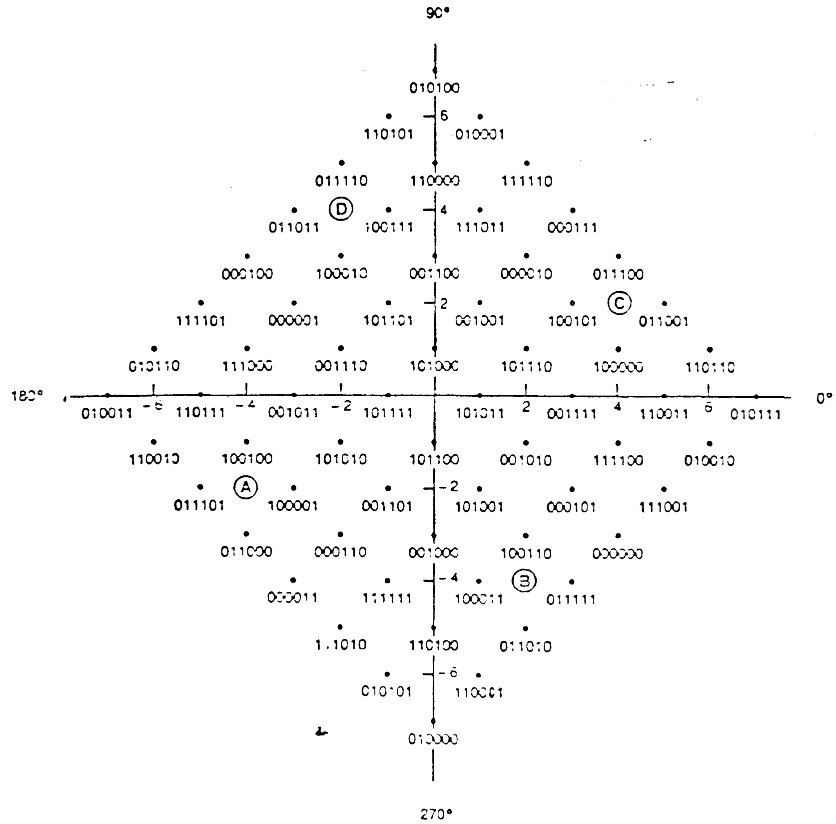
Signal space diagram at 4800 bit/s

V.29 Constellations

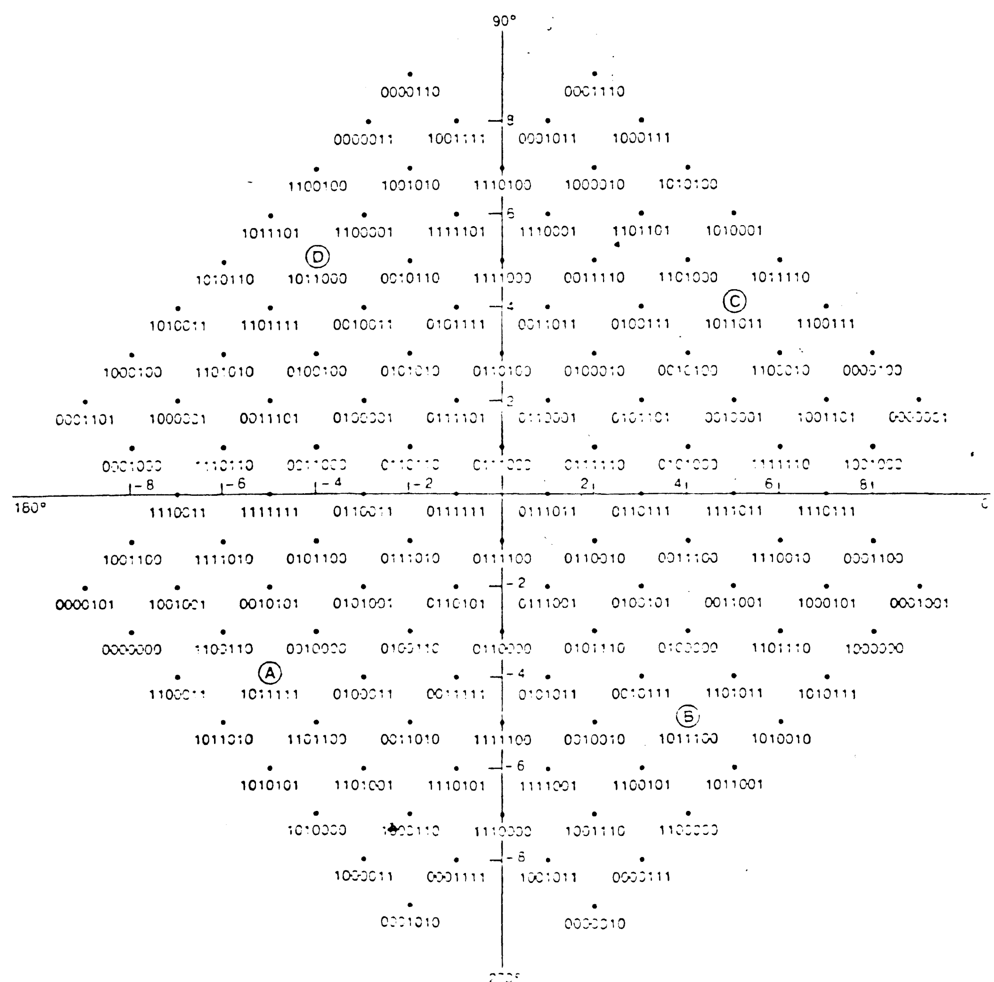


Bell 209 Constellation

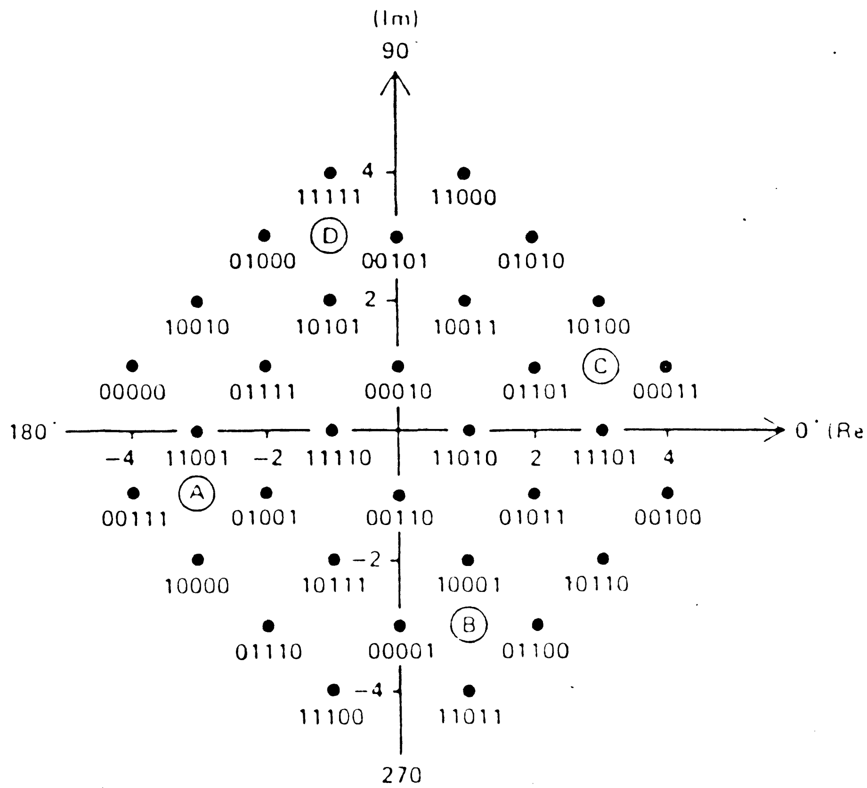
9600 BPS SYNCHRONOUS



12,000 BPS SYNCHRONOUS MODEM V.CC Constellation



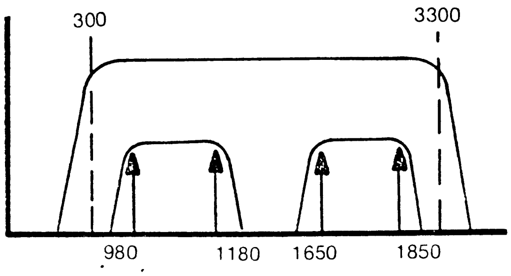
14,400 BPS SYNCHRONOUS MODEM V.CC Constellation



Constellation

32-point signal structure with trellis coding for 9600 bit/s
and states A B C D used at 4800 bit/s and for training

C. Common Types of Modems used Internationally



Types

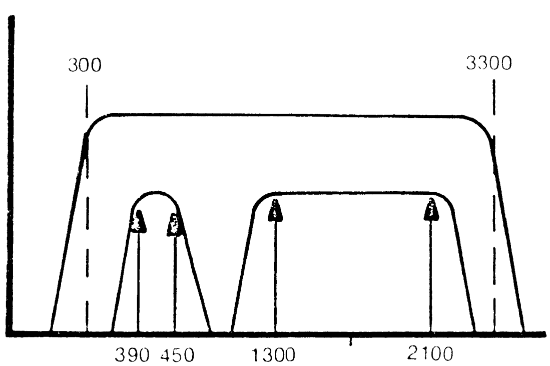
. V.21 O/A LP
0-300 bps, async, FSK,
Full duplex

. V.21 A/A LP
0-300 bps, async, GSTN
Auto answer, FSK
Full duplex
Connect sequency
Similar to 103 series

	ORIGINATE		ANSWER	
TRANSMIT	SPACE	1180	SPACE	1850
	MARK	980	MARK	1650
RECEIVE	SPACE	1850	SPACE	1180
	MARK	1650	MARK	980

V.21 Spectral Content

V.21 0 to 300 bps FSK, Async



Types

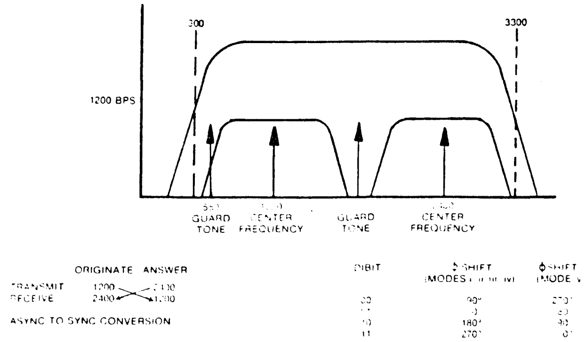
. V.23 0 to 1200 (1800) bps
FSK primary channel,
0 to 75 bps or
0 to 150 bps
FSK backward channel,
Async, Half Duplex,
PSTN, or 2w/4w private
line

Connect sequence similar
to 202 series

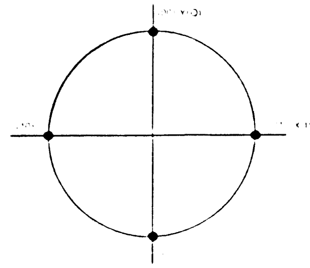
	FORWARD CHANNEL	BACKWARD CHANNEL
MARK	1300	390
SPACE	2100	450

V.23 Spectral Content

V.23, Primary Channel 9 to 1200(1800) bps, backward FSK Channel, Async



V.22, 1200/600 BPS, DCPSK, SYNC OR ASYNC



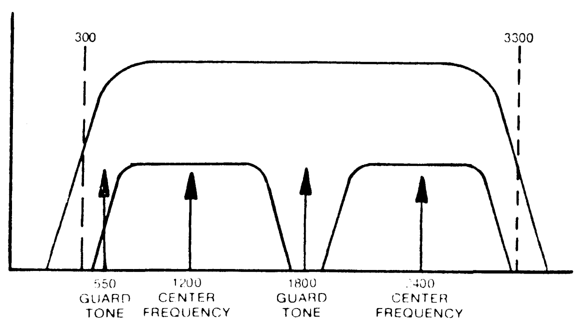
V.22 Constellation

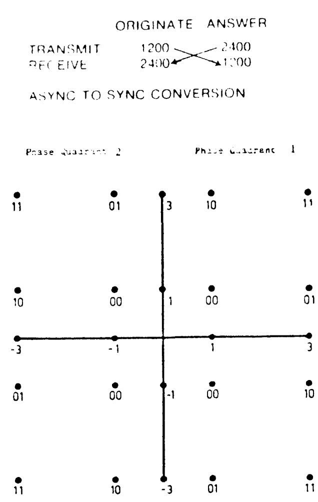
Types

- V.22
  2 wire, GSTN, 1200 bps
  sync or async
  0 to 300 bps
  async
  full duplex

- V.22 bis
  2 wire GSTN
  2400/1200 bps,
  sync or async
  full duplex

  Connect sequence similar to 212



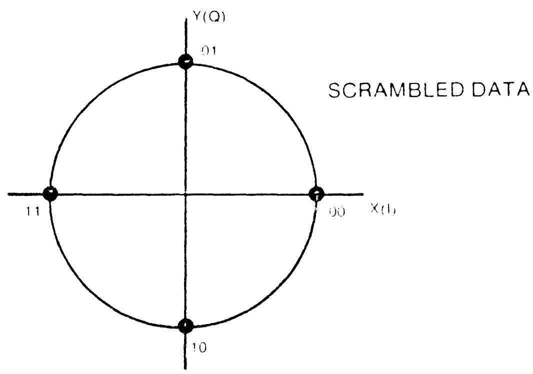


V.22 bis Constellation

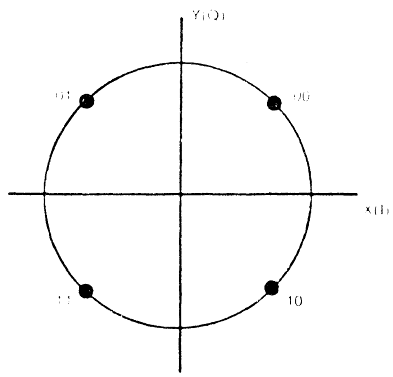
Modulation

Tribit	Phase Shift
001	0°
000	45°
010	90°
011	135°
111	180°
110	225°
100	270°
101	315°

V.22/V.22 bis 2400/1200/0 to 300, Async/Sync



V.26 Alternative "A" Modulation



V.26 Alternative "B" Modulation

MODULATION

DIBIT	PHASE SHIFT A	PHASE SHIFT B
00	0	45
01	90°	135
11	180°	225
10	270	315

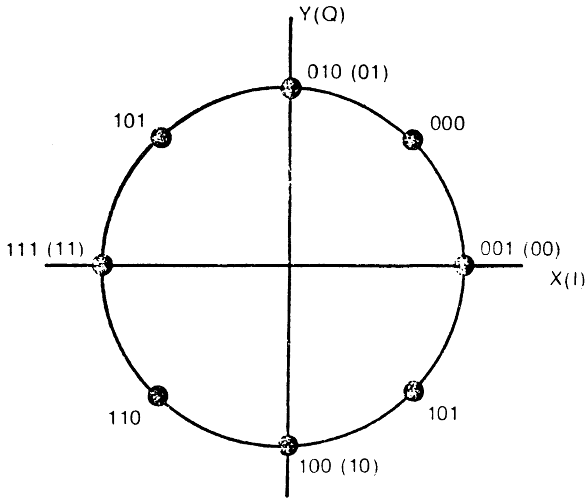
Types

. V.26
  2400 bps
  sync, half duplex,
  4 wire, private line

. V.26 bis
  2400/1200 bps
  sync, half duplex,
  4 wire, GSTN

Connect sequence similar to 202 series

V.26 Modem - 2400/1200 bps Sync



(DIBITS) FALLBACK MODE

V.27 Constellation

MODULATION

TRIBIT	DIBIT*	PHASE SHIFT
001	00	0°
000		45°
010	01	90°
011		135°
111	11	180°
110		225°
100	10	270°
101		315°

*DIBIT V 27 BIS AND V 27 TER

Types

- V.27
  4800 bps, sync
  4 wire private line,
  manual equalizer
  half duplex

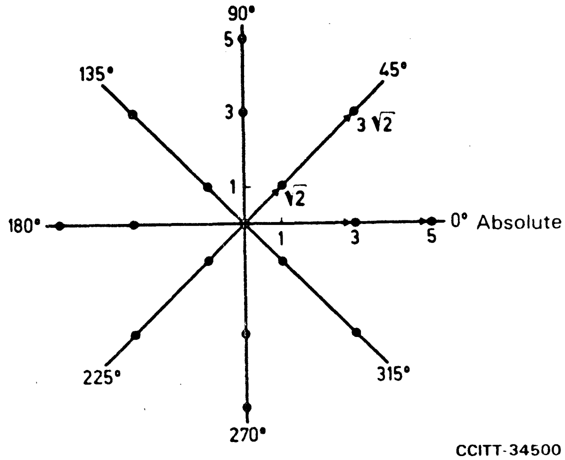
- V.27 BIS
  4800/2400 bps, sync
  4 wire private line,
  automatic equalization
  half duplex

- V.27 TER
  4800/1400 bps
  Sync
  GSTN
  half duplex

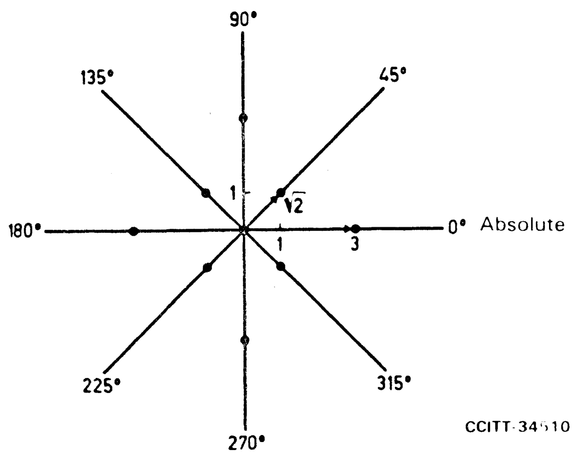
Connect sequence similar to 202 series

Data scrambled

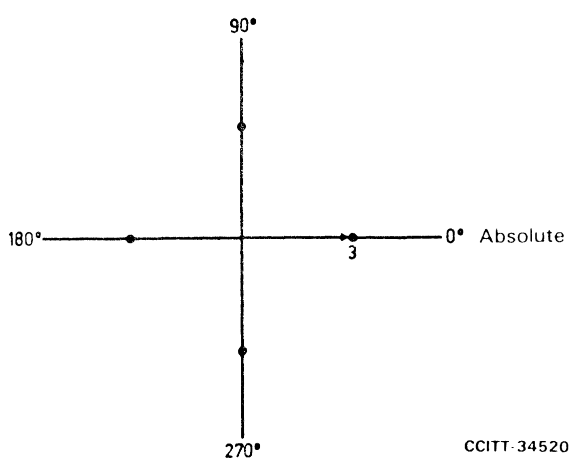
V.27 Series Modem - 4800/2400 BPS Sync



Signal space diagram at 9600 bit/s



Signal space diagram at 7200 bit/s



Signal space diagram at 4800 bit/s

V.29 CONSTELLATION S

Types

- V.29
  9600/7200/4800 bps,
  Sync,
  4 wire private line
  Automatic equalizing

- V.29 Mux
  Time division
  2, 3, 4 channels

  Connect sequence similar
  to 202 series

  Data scrambled

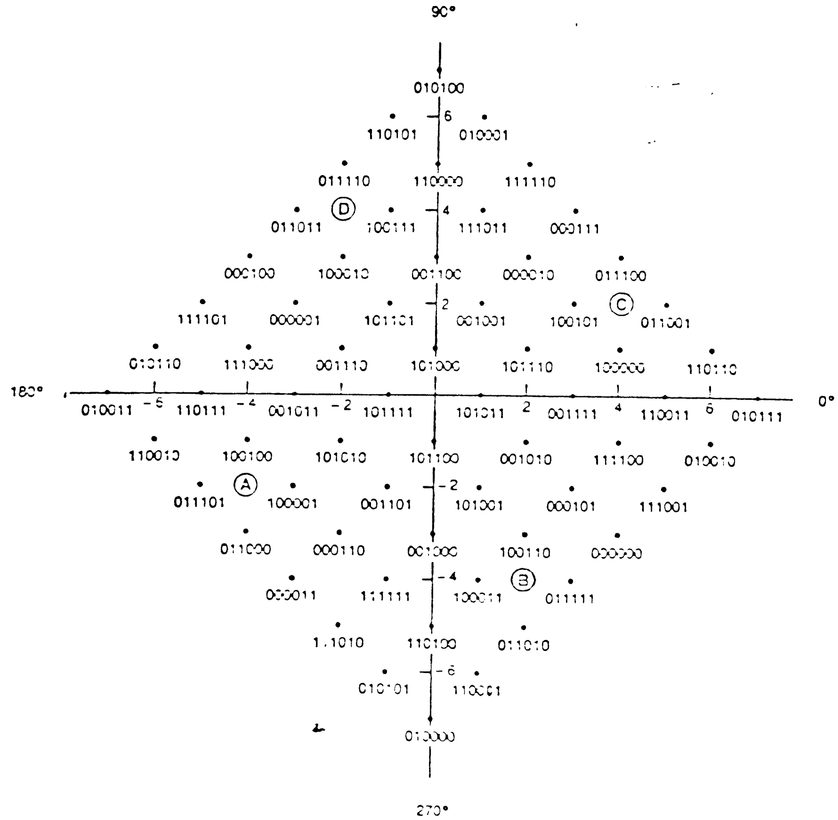
Modulation QAM (DC PSK and Amplitude)

QUADBITS

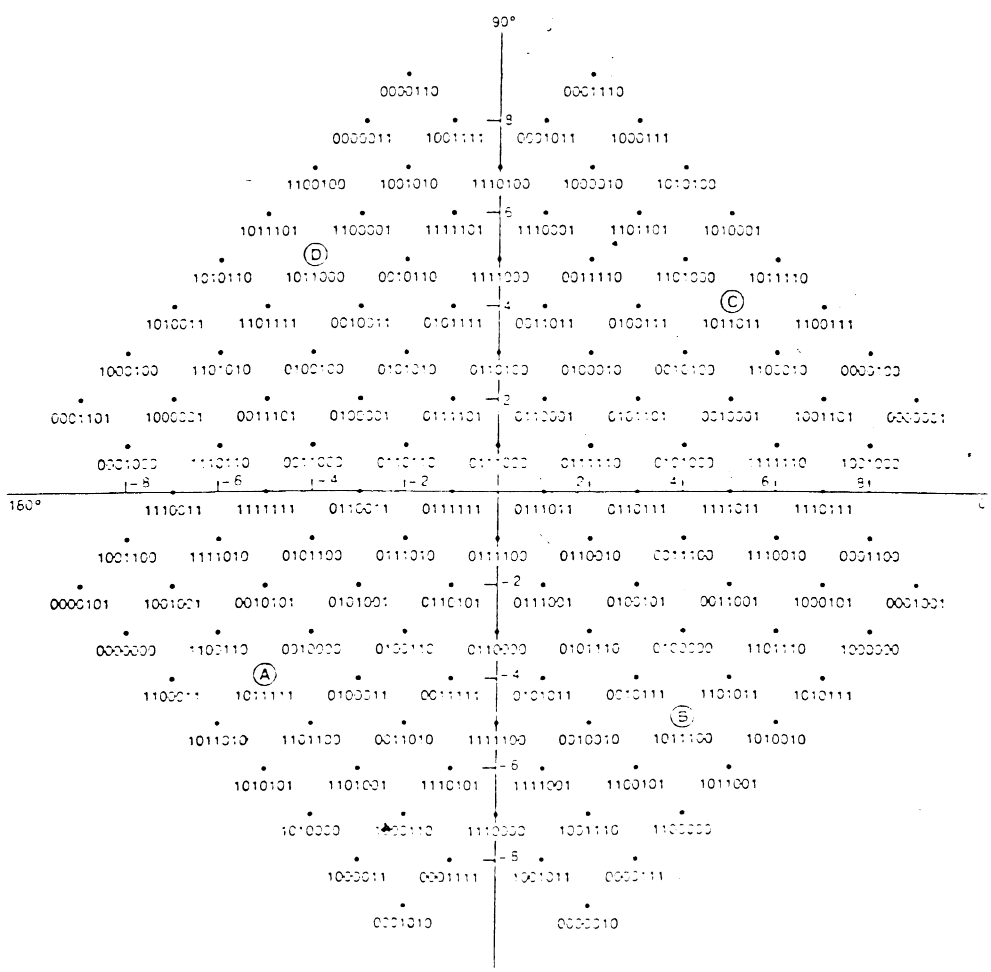
Q2	Q3	Q4	PHASE CHANGE
0	0	1	0°
0	0	0	45°
0	1	0	90°
0	1	1	135°
1	1	1	180°
1	1	0	225°
1	0	0	270°
1	0	1	315°

Q1	ABSOLUTE PHASE	RELATIVE SIGNAL ELEMENT AMPLITUDE
0 1	0°, 90°, 180°, 270°	3 5
0 1	45°, 135°, 225°, 315°	$\sqrt{2}$ $3\sqrt{2}$

V.29 Modem - 9600/7200/4800 BPS, Sync



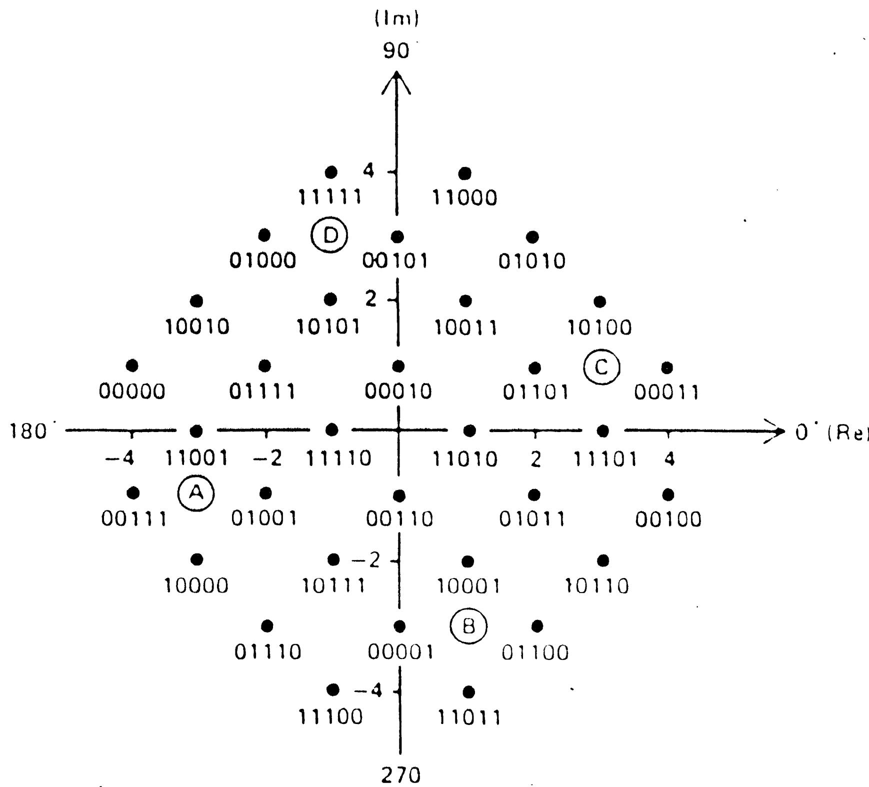
12,000 BPS SYNCHRONOUS MODEM V.33 Constellation



14,400 BPS SYNCHRONOUS MODEM V.33 Constellation

Type

. V.32
  9600/7200/4800 bps
  GSTN - 2 wire
  full duplex
  sync/async
  Trellis encoding
  Echo channeling



32-point signal structure with trellis coding for 9600 bit/s and states A B C D used at 4800 bit/s and for training

V.32 - 9600/7200/4800 BPS, Async/Sync Full Duplex

(4) <u>Data Service Units (DSU) and Channel Service Units (CSU)</u> - DCE equipment used on DDS network.

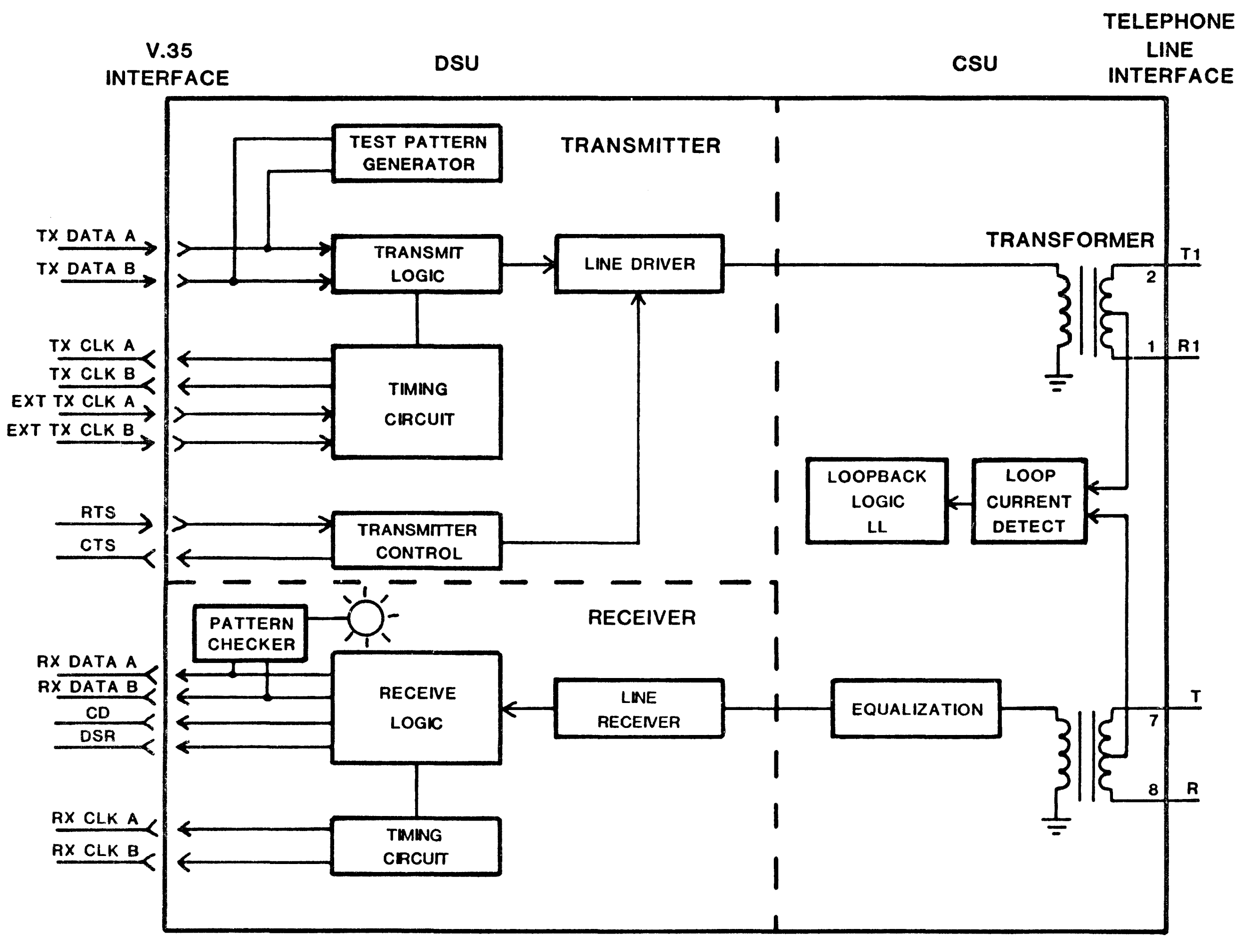
<u>Data Service Unit (DSU)</u> - DCE device that uses Baseband Bi-Polar Return to Zero (RZ) signaling on DDS networks.

- synchronous timing is derived from incoming signal
- provides control and test function
- provides interface to DTE via V.35 digital interface at 56K bps
- provides interface to DTE via RS232C digital interface at 2.4K, 4.8K and 9.6K

<u>Channel Service Unit (CSU)</u> - registered protective device that interfaces to the DDS network.

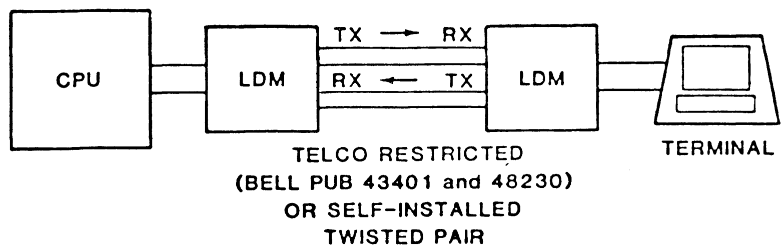
- FCC Part 68 Registered
- provides protection for Central Office (CO) equipment
- provides receiver equalization
- provides for remote testing for telephone (CO) or remote DSU

<u>DSU/CSU</u> - a unit containing a DSU and CSU in one housing.

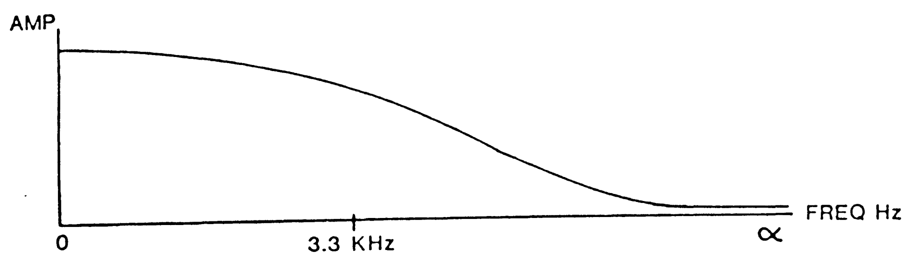


Basic Elements of a Data Service Unit/Channel
Service Unit (DSU/CSU)

(5) Limited Distance Modem (LDM) - modem used over short distances (usually less than 25 miles) via Telco restricted metallic circuit (48230) or twisted pair metallic circuit (self-installed). Uses carrier modulation or base-band type signalling.



. Will not normally operate with lines using loading coils. Because loaded lines limit the bandwidth.



Frequency Response of an Unloaded Line

. Distance is a function of bit rate and cable size.

As bit rate increases, distance possible decreases.

As cable size decreases, the speed possible decreases.

As cable size decreases, the distance possible decreases.

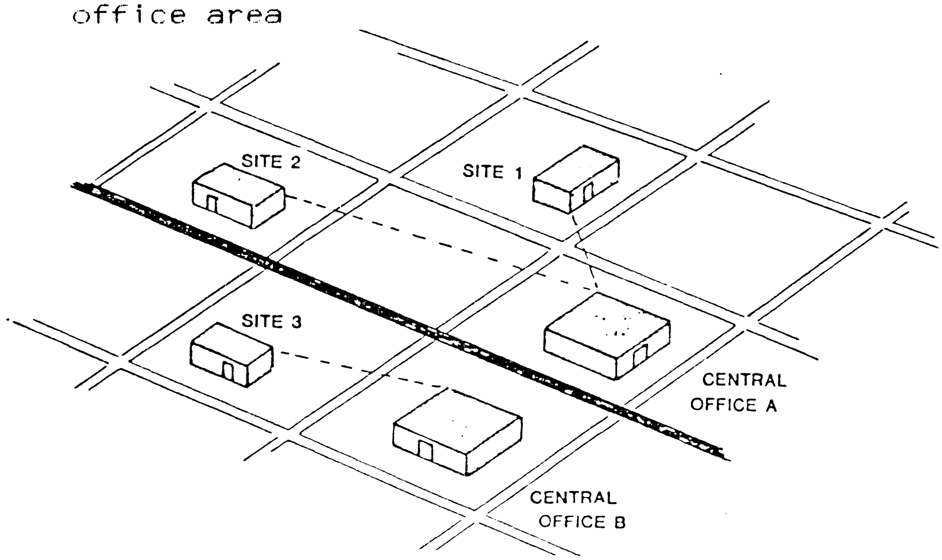
Restricted output level.

Data Rate (BPS)	0 dBm Transmitted Power Twisted Pair Wire Guage (AWG)				Telco Restricted Mode Bell 43401 and 48230 Wire Guage (AWG)				Transmitted Power Level in Telco Restricted Mode Bell 43401 and 48230
	19	22	24	26	19	22	24	26	
2400	23	15	12	9	23	15	12	9	0
4800	17	12	8	6	17	12	8	6	-6
7200	15	9	7	5	12	7	5	4	-12
9600	14	8	6	4	9	5	4	3	-16
19200	10	6	4	3	6	4	3	2	-20

Typical Transmission Range (Miles) of a Limited Distance
Modem (LDM)

. On Telco restricted leased lines, the physical distance between modem and actual wire distance is rarely equal unless the Telco central office is approximately between the two LDM's.

. LDM's must be located within one central office area



. Do not normally require DC continuity (transformer coupled).

. Non-loaded Metallic lines may require extra work by the telephone company to insure that there are no loading coils or bridge taps (extra length of undetermined length cable) on the intended circuit. This may cause order time to be extended.

. No standard types - one manufacturer not compatible with another.

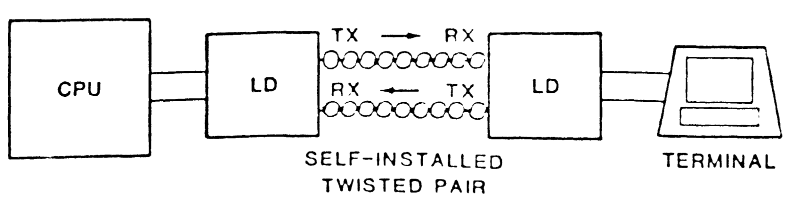
(C) Line Driver (LD) - DCE devices that use drivers as transmitted and differential amplifies as receivers (balanced circuit)

. Used over short distances (usually less than 0.5 miles) via self installed twisted pair.

. Will not operate with lines using loading coils.

. Requires DC continuity (directly coupled to line--normally polarity sensitive).

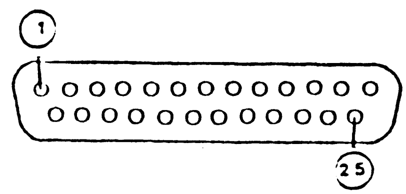
. No standard types - one manufacturer not compatible with another.



9. **Digital Interfaces**

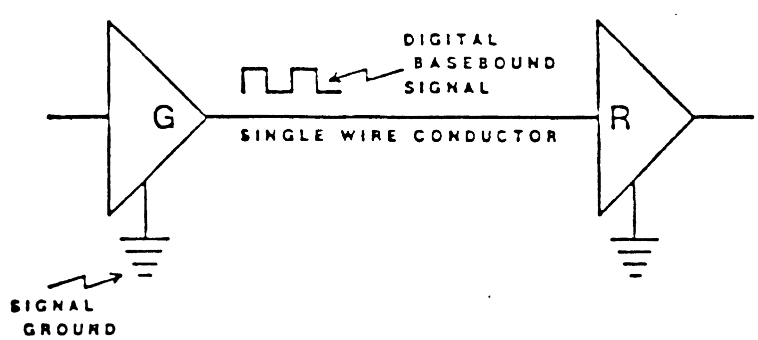
Interface between the data terminal equipment (DTE) and Data Circuit-Terminating Equipment (DCE) or communications Interface Units (CIU).

A. RS232-C - EIA- TR 30 Group Standard Interface used to interface DTE's to modems (DCE).
- 25 pin connector used for interface



DB 25 Connector

- defines interface leads for data transfer, timing, and handshaking information (control)
- electrical characteristics
  Mark (off, 1) - 3V to -25V (normally -12V)
  Space (on 0) +3V to +25V (normally +12V)
  Undefined -3V to +3V
- Limited to 50 ft. at 20 Kbits/s (but can be operate over longer distances at lower rates)
- Unbalanced signals, thus susceptable to crosstalk and noise pickup
- One wire (single-end) used for each signal with common return (signal ground - pin 7)



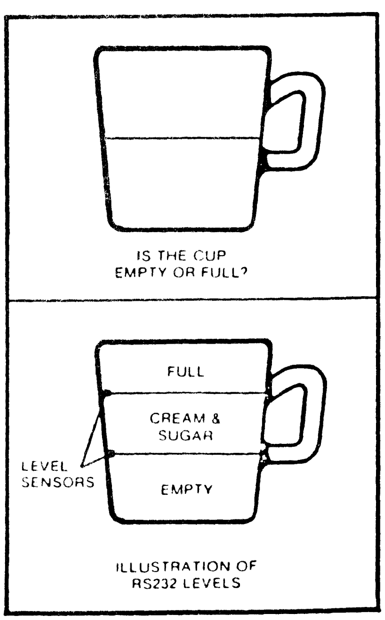
RS-232 Unbalanced Circuit

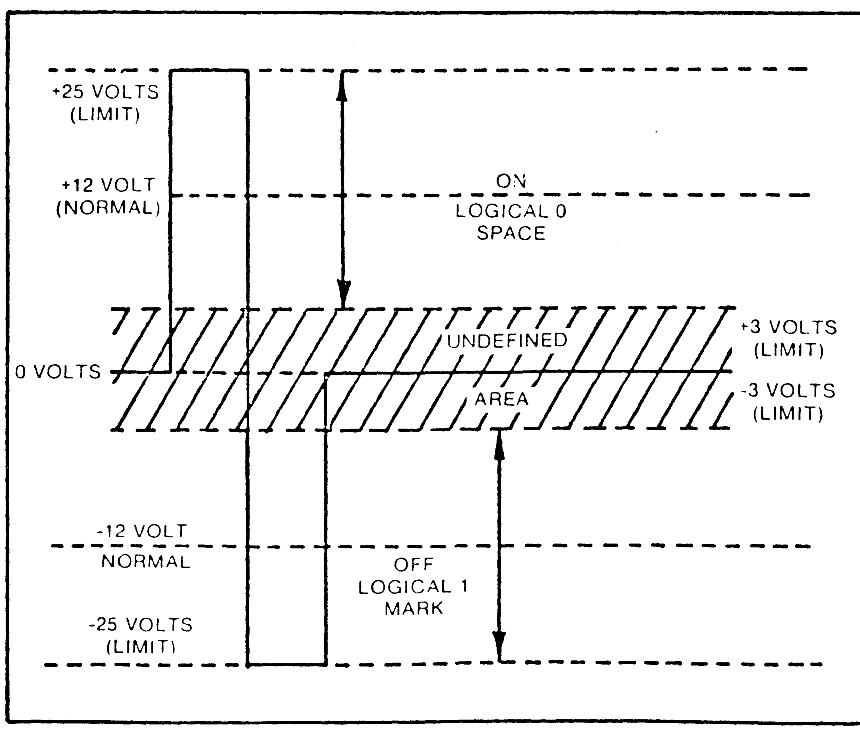
- Compatible with CCITT V.24/V.28
  V.24 - signal description
  V.28 - electrical characteristics
- Similar to MIL-STD-188C (not fully compatible)

PIN	NAME	TO DTE ←	TO DCE →	FUNCTION	CIRCUIT (CCITT)	(EIA)
1	FG			FRAME GROUND	101	(AA)
2	TD		→	TRANSMITTED DATA	103	(BA)
3	RD	←		RECEIVED DATA	104	(BB)
4	RTS		→	REQUEST TO SEND	105	(CA)
5	CTS	←		CLEAR TO SEND	106	(CB)
6	DSR	←		DATA SET READY	107	(CC)
7	SG			SIGNAL GROUND	102	(AB)
8	DCD	←		DATA CARRIER DETECT	109	(CF)
9		←		POSITIVE DC TEST VOLTAGE		
10		←		NEGATIVE DC TEST VOLTAGE		
11				UNASSIGNED		
12	(S) DCD	←		SEC. DATA CARRIER DETECT	122	(SCF)
13	(S) CTS	←		SEC. CLEAR TO SEND	121	(SCB)
14	(S) TD		→	SEC. TRANSMITTED DATA	118	(SBA)
15	TC	←		TRANSMITTER CLOCK	114	(DB)
16	(S) RD	←		SEC. RECEIVED DATA	119	(SBB)
17	RC	←		RECEIVER CLOCK	115	(DD)
18			→	RECEIVER DIBIT CLOCK		
19	(S) RTS		→	SEC. REQUEST TO SEND	120	(SCA)
20	DTR		→	DATA TERMINAL READY	108.2	(CD)
21	SQ	←		SIGNAL QUALITY DETECT	110	(CG)
22	RI	←		RING INDICATOR	125	(CE)
23			→	DATA RATE SELECT	1/112	(CH/CI)
24	(TC)		→	EXT. TRANSMITTER CLOCK	113	(DA)
25			→	BUSY		

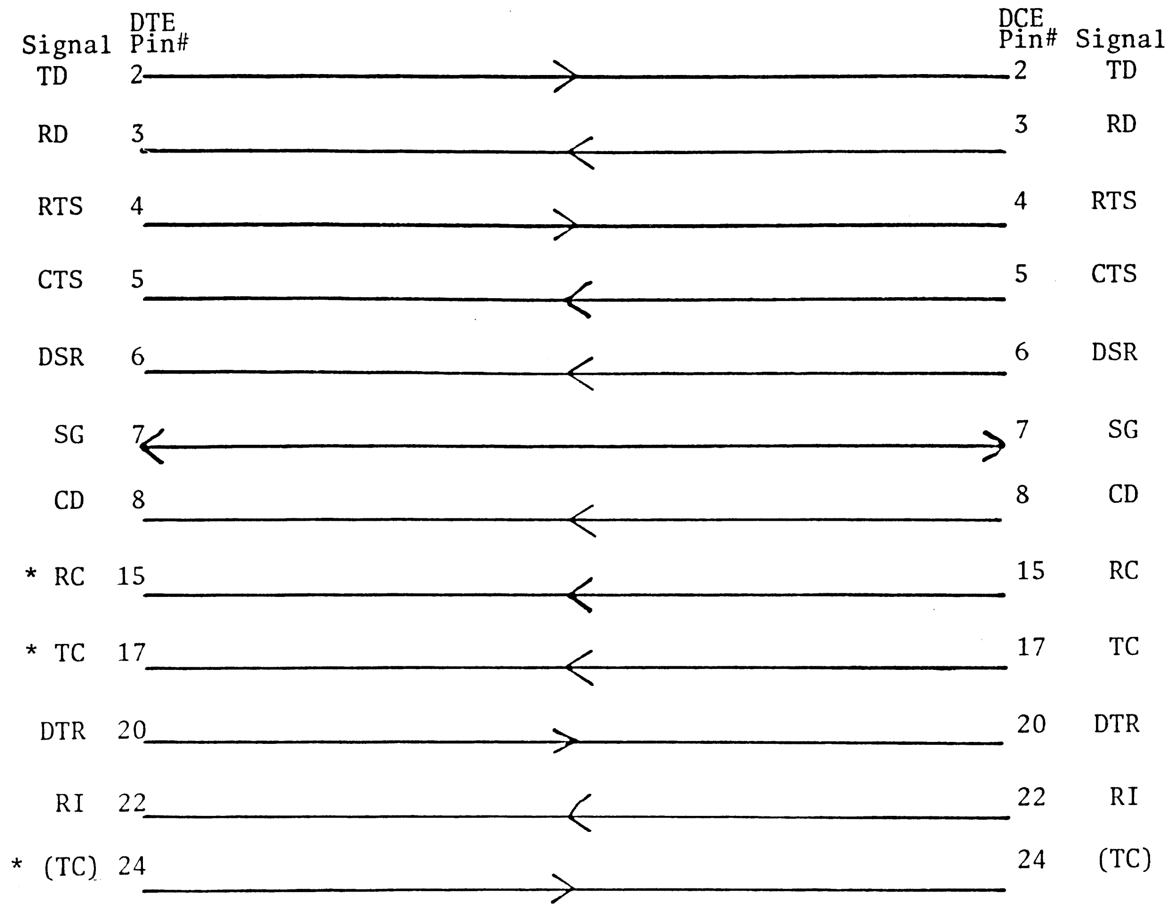
- POSITIVE VOLTAGE EQUALS BINARY ZERO, SPACE, ON
- NEGATIVE VOLTAGE EQUALS BINARY ONE, MARK, OFF

EIA RS232C/CCITT V.24 Interface Categories



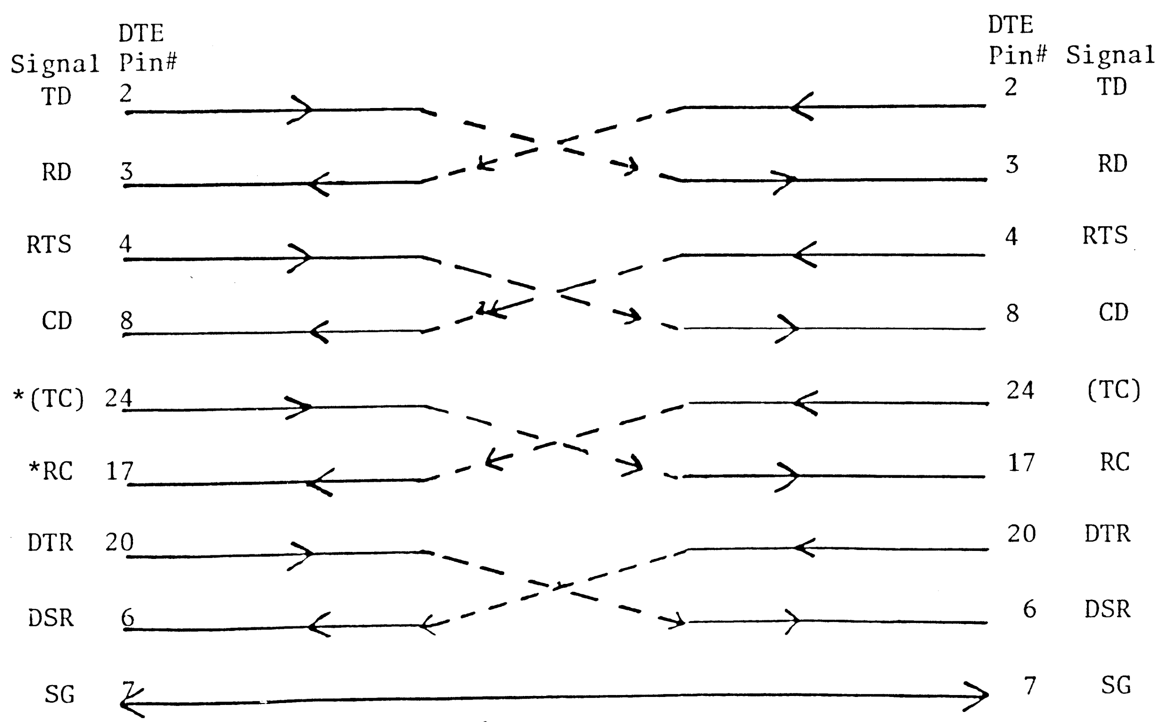


EIA RS232C/CCITT V.28 Electrical Characteristics



*Required for synchronous modems

RS232 Pin to Pin Cable DTE to DCE



*Required for synchronous Devices

RS232 Cross Over Cable DTE to DTE

- Signal Definitions

  - Frame Ground (FG) or Protective Ground
    EIA Circuit AA (CCITT 101)
    Direction: Not applicable
    Pin 1

    This conductor shall be electrically bonded to the machine or equipment frame. It may be connected further to external grounds as required by applicable regulations.

  - Signal Ground (SG) or Common Return
    EIA Circuit AB (CCITT 102)
    Direction: Not applicable
    Pin 7

    This conductor establishes the common ground reference potential for all interchange circuits except Circuit AA (Protective Ground). Within the Data Communications Equipment (DCE), this circuit shall be brought to one point, and it shall be possible to connect this point to Circuit AA by means of a wire strap inside the equipment. This wire strap can be connected or removed at installations, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

  - Transmitted Data (TD)
    EIA Circuit BA (CCITT 103)
    Direction: TO DCE
    Pin 2

    Signals on this circuit are generated by the Data Terminal Equipment (DTE) and are transferred to the local transmitting signal converter for transmission of data remote DTE.

    The DTE shall hold Circuit BA (Transmitted Data) in marking condition during intervals between characters or words, and at all times when no data is being transmitted.

    In all systems, the DTE shall not transmit data unless an ON condition is present on all of the following four circuits, where implemented.

    1. Circuit CA (Request to Send)
    2. Circuit CB (Clear to Send)
    3. Circuit CC (Data Set Ready)
    4. Dircuit CD (Data Terminal Ready)

All Data signals that are transmitted across the interface on the interchange circuit BA (Transmitted Data) during the time an ON condition is maintained on all of the above four circuits, where implemented, shall be transmitted to the communication channel.

- Received Data(RD)
  EIA Circuit BB (CCITT 104)
  Direction: FROM DCE
  Pin 3

  Signals on this circuit are generated by the receiving signal converter in response to data signals received from remote DTE via the remote transmitting signal converter. Circuit BB (Received Data) shall be held in the binary ONE (Marking) condition at all times when Circuit CF (Received Line Signal Detector) is in the Off condition.

- Request to Send (RTS)
  EIA Circuit CA (CCITT 105)
  Direction: TO DCE
  Pin 4

  This circuit is used to condition the local DCE for data transmission and, on a half duplex channel, to control the direction of data transmission of the local DCE.

  On one-way only channels or duplex channels, the ON condition maintains the DCE in the transmit mode. The OFF conditions maintains the DCE in a non-transmit mode.

  On a half duplex channel, the ON condition maintains the DCE in the transmit mode and inhibits the receive mode. The OFF condition maintains the DCE in the receive mode.

  A transition from OFF to ON instructs the DCE to enter the transmit mode. The DCE responds by taking such action as may be necessary and indicates completion of such actions by turning ON Circuit CB (Clear to Send), thereby indicating to the DTE that data may be transferred across the interface point on interchange Circuit BA (Transmitted Data).

  A transition from ON to OFF instructs the DCE to complete the transmission of all data which was previously transferred across the interface point to interchange circuit BA and then assume a non-transmit mode or a receive mode as may be appropriate. The DCE responds to this instruction by turning OFF Circuit CB (Clear to Send) when it is prepared to again respond to a subsequent ON condition of Circuit CA.

NOTE: A non-transmit mode does not imply that all line signals have been removed from the communication channel.

When Circuit CA is turned OFF, it shall not be turned ON again until Circuit CB has been turned Off by the DCE.

An ON condition is required on Circuit CA as well as on Circuit CB, Circuit CC (Data Set Ready), and, where implemented, Circuit CD (Data Terminal Ready) whenever the DTE transfers data across the interface on interchange Circuit BA.

It is permissible to turn Circuit CA ON at any time when Circuit CB is OFF regardless of the condition of any other interchange circuit.

- Clear to Send (CTS)
  EIA Circuit CB (CCITT 106)
  Direction: FROM DCE
  Pin 5

  Signals on this circuit are generated by the DCE to indicate whether or not the data set is ready to transmit data.

  The ON condition together with the ON condition on interchange circuits CA, CC, and, where implemented, CD, is an indication to the DTE that signals presented on Circuit BA (Transmitted Data) will be transmitted to the communications channel.

  The Off condition is an indication to the DTE that it should not transfer data across the interface to interchange Circuit BA.

  The ON condition of Circuit CB is a response to the occurrence of a simultaneous ON condition on Circuits CC (Data Set Ready) and circuit CA (Request to Send), delayed as may be appropriate to the DCE for establishing a data communication channel (including the removal of the MARK HOLD clamp from the Received Data interchange circuit of the remote data set) to a remote DTE.

Where Circuit CA (Request to Send) is not implemented in the data communicatin equipment with transmitting capability, Circuit CA shall be assumed to be in the ON condition at all times, and Circuit CB shall respond accordingly.

- Data Set Ready (DSR)
  EIA Circuit CC (CCITT 107)
  Direction: FROM DCE
  Pin 6

  Signals on this circuit are used to indicate the status of the local data set.

  The ON condition on this circuit is presented to indicate that -

  a) The local DCE is connected to a communication channel ("OFF HOOK" in a switched service), AND

  b) the local DCE is not in test (local or remote), talk (alternate voice) or dial mode, AND

  c) the local DCE has completed, where applicable,

     1. any timing functions required by the switching system to complete call establishment, and

     2. the transmission of any discreet answer tone, the duration of which is controlled solely by the local data set.

  Where the local DCE does not transmit an answer tone, or where the duration of the answer tone is controlled by some action of the remote data set, the ON condition is presented as soon as all the other above conditions (a, b, and c-1) are satisfied.

  This circuit shall be used only to indicate the status of the local data set. The ON condition shall not be interpreted as either an indication that a communication channel has been established to a remote data station or the status of any remote station equipment.

  The OFF condition shall appear at all other times and shall be an indication that the DTE is to disregard signals appearing on any other interchange circuit with the exception of circuit

CE (Ring Indicator). The OFF condition shall not impair the operation of Circuit CE or Circuit CD (Data Terminal Ready).

When the OFF condition occurs during the progress of a call before Circuit CD is turned OFF, the DTE shall interpret this as a lost or aborted connection and take action to terminate the call. Any subsequent ON condition of Circuit CC is to be considered a new call.

NOTE: Attention should be called to the fact that if a data call is interrupted by alternate voice communication, Circuit CC will be in the OFF condition during the time that voice communication is in progress. The transmission or reception of the signals required to condition the communication channel or DCE in response to the ON condition of interchange Circuit CA (Request to Send) of the transmitting DTE will take place after circuit CC comes ON, but prior to the ON condition on Circuit CB (Clear to Send) or Circuit CF (Received Line Signal Detector).

- <u>Data Terminal Ready (DTR)</u>
  EIA Circuit CC (CCITT 108.2)
  Direction: To DCE
  Pin 20

  Signals on this circuit are used to control switching of the DCE to the communication channel. The ON condition prepares the DCE to be connected to the communication channel and maintains the connection established by external means (e.g., manual call origination, manual answering, or automatic call origination).

  When the station is equipped for automatic answering of received calls and is in the automatic answering mode, connection to the line occurs only in response to a combination of a ringing signal and the ON condition of Circuit CD (Data Terminal Ready). However, the DTE is normally permitted to present the ON condition Circuit CD whenever it is ready to transmit or receive data, except as indicated below.

  The OFF condition causes the DCE to be removed from the communication channel following the completion of any "in process" transmission. See Circuit BA (Transmitted Data). The Off Condition shall not disable the operation of Circuit CE (Ring Indicator).

In switched network applications, when circuit CD is turned OFF, it shall not be turned ON again until Circuit CC (Data Set Ready) is turned OFF by the DCE.

- Ring Indicator (RI)
  EIA Circuit CE (CCITT 125)
  Direction: From DCE
  Pin 22

  The ON condition of this circuit indicates that a ringing signal is being received on the communication channel .

  The ON condition shall appear approximately coincident with the ON segment of the ringing cycle (during rings) on the communication channel.

  The OFF condition shall be maintained during the OFF segment of the ringing cycle (between "rings") and at all other times when ringing is not being received. The operation of this circuit shall not be disabled by the OFF condition on Circuit CD Data Terminal Ready).

- Data Carrier Detect (DCD or Received Line Signal Detector
  EIA Circuit CF (CCITT 109)
  Pin 8

  The ON condition on this circuit is presented when the DCE is receiving a signal which meets its suitability criteria. These criteria are established by the DCE manufacturer.

  The OFF condition indicates that no signal is being received or that the received signal is unsuitable for demodulation.

  The OFF condition of Circuit CF (Received Line Signal Detector) shall cause Circuit BB (Received Data) to be clamped to the Binary One (Marking) condition.

  The indications on this circuit shall follow the actual onset or loss of signal by appropriate guard delays.

  On half duplex channels, Circuit CF is held in the OFF condition whenever Circuit CA (Request to Send) is in the ON condition and for a brief interval of time following the ON to OFF transition of Circuit CA (see Circuit BB).

- Signal Quality Detector (SQ)
  EIA Circuit CG (CCITT 110)
  Direction: FROM DCE
  Pin 21

  Signals on this circuit are used to indicate whether or not there is a high probability of an error in the received data.

  An ON condition maintained whenever there is no reason to believe that an error has occurred.

  An OFF condition indicates that there is a high probability of an error. It may, in some instances, be used to call automatically for the retransmission of the previously transmitted data signal. Preferably, the response of this circuit shall be such as to permit identification of individual questionable signal elements on Circuit BB (Received Data).

- Data Rate Select or Data Signal Rate Selector
  EIA Circuit CH/CI (CCITT 111)
  Direction: TO DCE
  Pin 23

  Signals on this circuit are used to select between the two data signaling rates in the case of dual rate synchronous data sets or the two ranges of data signaling rates in the case of dual range non-synchronous data sets.

  An ON condition shall select the higher data signaling rate or range of rates.

  The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

- Data Rate Select or Data Signal Rate Selector
  EIA Circuit ~~CH~~/CI (CCITT 112)
  Direction: FROM DCE
  Pin 23

  Signals on this circuit are used to select between the two data signaling rates in the case of dual rate synchronous data sets or the two ranges of data signaling rates in the case of dual range non-synchronous data sets.

An On condition shall select the higher data signaling rate or range of rates.

The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

- <u>Ext. Transmitter Clock (TC)</u> or Transmitter Signal Element Timing
  EIA Circuit DA (CCITT 113)
  Direction: TO DCE
  Pin 24

  Signals on this circuit are used to provide the transmitting signal converter with signal element timing information.

  The ON to OFF transition shall nominally indicate the center of each signal element on Circuit BA (Transmitted Data). When Circuit DA is implemented in the DTE, the DTE shall normally provide timing information on this circuit whenever the DTE is in a POWER ON condition. It is permissible for the DTE to withhold timing information on this circuit for short periods provided Circuit CA (Request to Send) is in the OFF condition (For example, the temporary withholding of timing information may be necessary in performing maintenance tests within the DTE).

- <u>Transmitter Clock (TC)</u> or Transmitter Signal Element Timing
  EIA Circuit DB (CCITT 114)
  Direction: FROM DCE
  Pin 15

  Signals on this circuit are used to provide the DTE with signal element timing information. The DTE shall provide a data signal on Circuit BA (Transmitted Data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of the signal on Circuit DB. When Circuit DB is implemented in the DCE, the DCE shall normally provide timing information on this circuit whenever the DCE is in a POWER ON condition. It is permissible for the DCE to withhold timing information on this circuit for short periods provided Circuit CC (Data Set Ready) is in the OFF condition (For example, the withholding of timing information may be necessary in performing maintenance tests within the DCE.

- Receiving Clock (RC) or Receiver Signal Element Timing
  EIA Circuit DD (CCITT 115)
  Direction: FROM DCE
  Pin 17

  Signals on this circuit are used to provide the DTE with received signal element timing information. The transition from ON to OFF condition shall nominally indicate the center of each signal element on Circuit BB (Received Data). Timing information on circuit DD shall be provided at all times when Circuit CF (Received Line Signal Detector) is in the ON condition. It may, but need not be present, following the ON to OFF transition of Circuit CF.

- Sec. Transmitted Data ((S)TD)
  EIA Circuit SBA (CCITT 118)
  Direction: TO DCE
  Pin 14

  The Circuit is equivalent to Circuit BA (Transmitted Data) except that it is used to transmit data via the secondary channel.

  Signals on this circuit are generated by the DTE and are connected to the local secondary channel transmitting signal converter for transmission of data to remote DTE.

  The DTE shall hold Circuit SBA (Secondary Transmitted Data) in marking condition during intervals between character or words and at all times when no data is being transmitted.

  In all systems, the DTE shall not transmit data on the secondary channel unless an ON condition is present on all of the following four circuits, where implemented:

  1. Circuit SCA - Secondary Request to Send
  2. Circuit SCB - Secondary Clear to Send
  3. Circuit CC - Data Set Ready
  4. Circuit CD - Data Terminal Ready

  All data signals that are transmitted across the interface on interchange Circuit SBA during the time when the above conditions are satisfied shall be transmitted to the communications channel.

When the secondary channel is usable only for circuit assurance or to interrupt the flow of data in the primary channel (less than 10 baud capability), Circuit SBA (Secondary Transmitted Data) is normally not provided, and the channel carrier is turned ON or OFF by means of Circuit SCA (Secondary Request to Send); Carrier OFF is interpreted as an "Interrupt" condition.

- <u>Sec. Received Data (S) RD</u>
  EIA Circuit SBB (CCITT 119)
  Direction: FROM DCE
  Pin 16

  This circuit is equivalent to Circuit BB (Received Data) except that it is used to receive data on the secondary channel.

  When the secondary channel is usable only for circuit assurance or to interrupt the flow of data in the primary channel, Circuit SBB is normally not provided. See interchange Circuit SCF (Secondary Received Line Signal Detector).

- <u>Sec. Request to Send (S) RTS</u>
  EIA Circuit SCA (CCITT 120)
  Direction: TO DCE
  Pin 19

  This circuit is equivalent to Circuit CA (Request to Send) except that it requests the establishment of the secondary channel instead of requesting the establishment of the primary data channel.

  Where the secondary channel is used as a backward channel, the ON condition of Circuit CA (Request to Send) shall disable Circuit SCA, and it shall not be possible to condition the secondary channel transmitting signal converter to transmit during any time interval when the primary channel transmitting signal converter is so conditioned. Where system considerations dictate that one or the other of the two channels be in transmit mode at all times but never both simultaneously, this can be accomplished by permanently applying an ON condition to Circuit SCA (Secondary Request to Send) and controlling both the primary and secondary channels, in complementary fashion, by means of Circuit CA (Request to Send). Alternatively, in this case, Circuit SCB need not be implemented in the interface.

When the secondary channel is usable only for circuit assurance or to interrupt the flow of data in the primary data channel, Circuit SCA shall serve to turn ON the secondary channel unmodulated carrier. The OFF condition of Circuit SCA shall turn OFF the secondary channel carrier and thereby signal an interrupt condition at the remote end of the communication channel.

- Sec. Clear to Send (S) CTS
  EIA SCB (CCITT 121)
  Direction: FROM DCE
  Pin 13

  This circuit is equivalent to Circuit CB (Clear to Send), except that it indicates the availability of the secondary channel instead of indicating the availability of the primary channel. This circuit is not provided where the secondary channel is usable only as a circuit assurance or an interrupt channel.

- Sec. Data Carrier Detect (S) DCD
  EIA SCF (CCITT 122)
  Direction: FROM DCE
  Pin 12

  This circuit is equivalent to Circuit CF (Received Line Signal detector) except that it indicates the proper reception of the secondary channel line signal instead of indicating the proper reception of a primary channel received line signal.

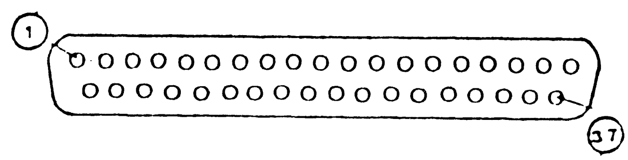
  Where the secondary channel is usable only as a circuit assurance or an interrupt channel (see Circuit SCA - Secondary Request to Send), Circuit SCF shall be used to indicate the circuit assurance status or to signal the interrupt. The ON condition shall indicate circuit assurance or a non-interrupt condition. The OFF condition shall indicate circuit failure (no assurance) or the interrupt condition.

(B) RS-449, RS-422, RS-423 - EIA Standard
<u>Discontinued</u> for use with Long Haul Modems

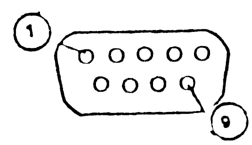
- RS-499 - Mother Document
  - Category I - Pair of Wires for each Signal
    - Balanced - RS-422
    - Unbalanced - RS-423
    - Primary Data, Timing, Five Selected Control Circuits
  - Category II - Single Wire for each Signal and Common Return
    - Return Unbalanced - RS-423
    - All circuits except primary data, timing, five selected control circuits.

- <u>Mechanical</u>

  37 position connector - primary circuits (category 1)



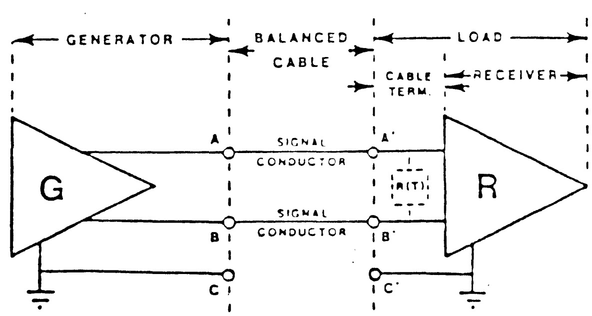
  9 position connector-secondary channel circuitry (category 2)



- <u>Electrical Characteristics</u>

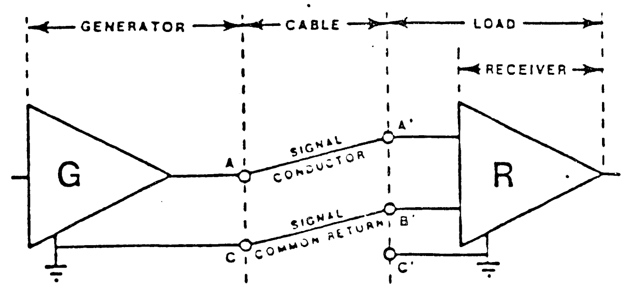
  Mark (off, 1) -4V to -6V, VRX .2V
  Space (on, 0) +4V to +6V, VRS .2V
  Voltage is limited to ±12V

- <u>RS-422</u> - use balanced drives and receives for rapid response and more noise immunity.

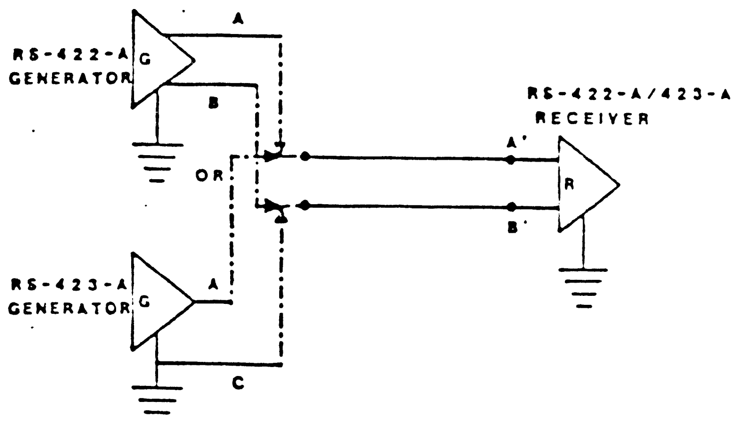


<u>RS449/RS422 Balanced Circuit</u>

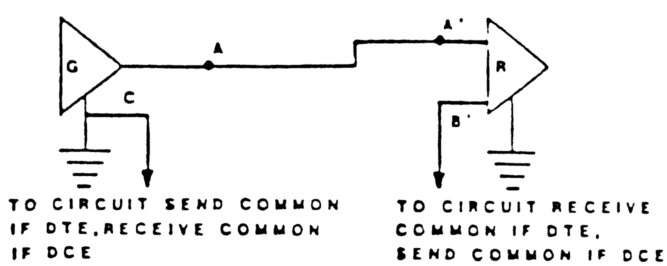
- RS-423 - use unbalanced drivers and receivers. since response time is less critical.



RS449/RS423 Unbalanced Circuit



(A)CATEGORYI CIRCUIT



(B)CATEGORYII CIRCUIT

- RS-423 - is compatible with RS232 by use of a pad and adapter cable. RS422 is not compatible with RS232.

- Longer distances and higher speeds to meet the advancing state of the art technology requirement.
  Up to 2M bps at 200 feet
  2400 bps at 2000 feet

- Compatible with CCITT V.10/X.26 and V.11/X.27

- Similar to MIL-STD-188-114

Circuit Name	Mnem	Cat	Pin No.	Circuit Classifi-Cation	Circuit Direction	Usage Options	Nearest RS232 Equivalent
Signal Ground	SG	11	19	G	-	M	Signal Ground
*Send Common	SC	11	37	G	To DCE	M	-
*Receive Common	RC	11	20	G	From DCE	M	-
*Terminal in Service	IS	11	28	C	To DEC	O	-
Incoming Call	IC	11	15	C	From DCE	A	Ring Indication
Terminal Ready	TR	1	12,30	C	To DCE	S	Data Terminal Ready
Data Mode	DM	1	11,29	C	From DCE	M	Data Set Ready
Send Data	SD	1	4,22	D	To DCE	M	Transmitted Data
Receive Data	RD	1	6,24	D	From DCE	M	Received Data
Terminal Timing	TT	1	17,35	T	To DCE	O	Xmit Sig Element DCE
Send Timing	ST	1	5,23	T	From DCE	T	Xmit Sig El Tim DTE
Receive Timing	RT	1	8,26	T	From DCE	T	Rec Sig El Timing
Request to Send	RS	1	7,25	C	To DCE	M	Request to Send
Clear to Send	CS	1	9,27	C	From DCE	M	Clear to Send
Receiver Ready	RR	1	13,31	C	From DCE	M	Carrier Detect
Signal Quality	SQ	11	33	C	From DCE	O	Signal Quality Detect
*New Signal	NS	11	34	C	To DCE	O	-
*Select Frequency	SF	11	16	C	To DCE	O	-
Signaling Rate Selector	SR	11	16	C	To DCE	O	Data Sig Rate Select
Signaling Rate Indication	SI	11	2	C	From DCE	O	Data Sig Rate Select
*Local Loopback	LL	11	10	C	To DCE	O	-
*Remote Loopback	RL	11	14	C	To DCE	O	-
*Test Mode	TM	11	18	C	From DCE	M	-
*Select Standby	SS	11	32	C	To DCE	O	-
*Standby Indicator	SB	11	36	C	From DCE	O	-
Shield	-	11	1	G	-	O	-
Spares	-	11	3,21	-	-	O	-

(a) circuits on the 37-pin main connector

Circuit Name	Mnem	Cat	Pin #	Cir. Class.	Circuit Directions	Usage Options	Nearest RS232 Equivalent
Signal Ground	SG	11	5	G	-	O	Signal Ground
Send Common	SC	11	9	G	To DCE	O	-
Receive Common	RC	11	6	G	From DCE	O	-
Secondary Send Data	SSD	11	3	D	To DCE	O	Secondary Transmit Data
Secondary Request to Send	SRS	11	7	C	To DCE	O	Secondary Request to Send
Secondary Clear to Send	SCS	11	8	C	From DCE	O	Secondary Clear to Send
Secondary Receiver Ready	SRR	11	2	C	From DCE	O	Secondary Rec. Line Signal Detect
Shield	-	11	1	G	-	O	-

(b) circuits on the 9-pin optional connector

Legend and Notes:

Circuit Classifications
- G=Ground or Common
- D=Data
- C=Control

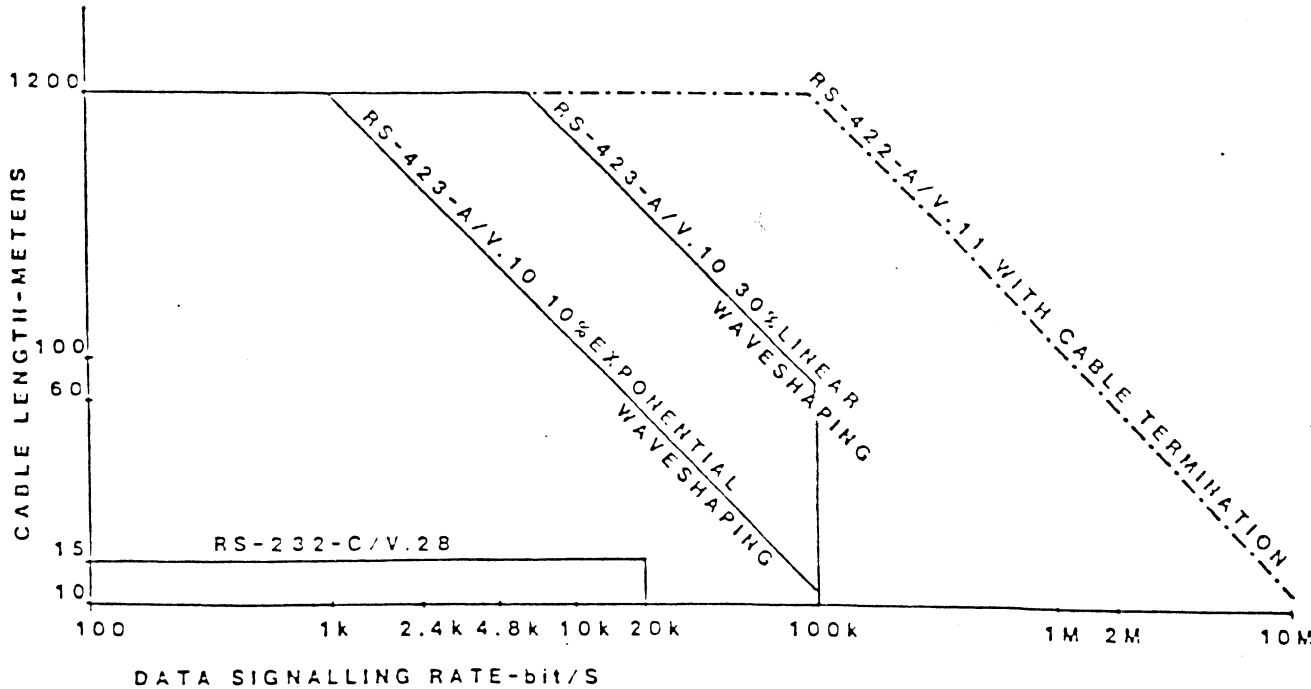
T = Test

Circuit Category
- 1=Category 1
- 11=Category 11

Usage Options
- M = Mandatory for all two-way communications channels
- S = Additional circuits required for all switched channels
- A = Additional circuits required for all switched channels with answering signaled across the interface
- T = Additional circuits required for synchronous primary channel
- O = Optional circuits

Other:
- * = New circuits not contained in RS232 Standard

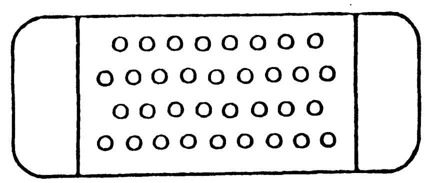
EIA RS449, RS422 and RS423, and
CCITT V.10/X.26 and V.11/X.27
Interface Categories



Comparison of Performance Characteristics
for RS232, RS422 and RS423

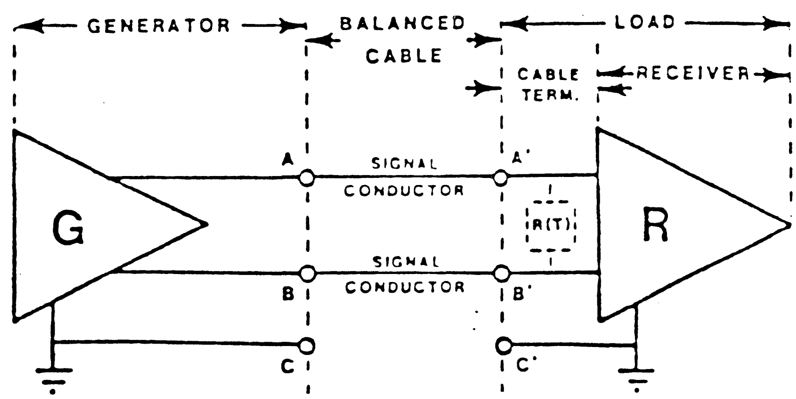
(C) CCITT V.35 - CCITT Standard Interface used to Interface DTE's to DSU/CSU's on Wide Band Modems

- Mechanical -34 pin connector

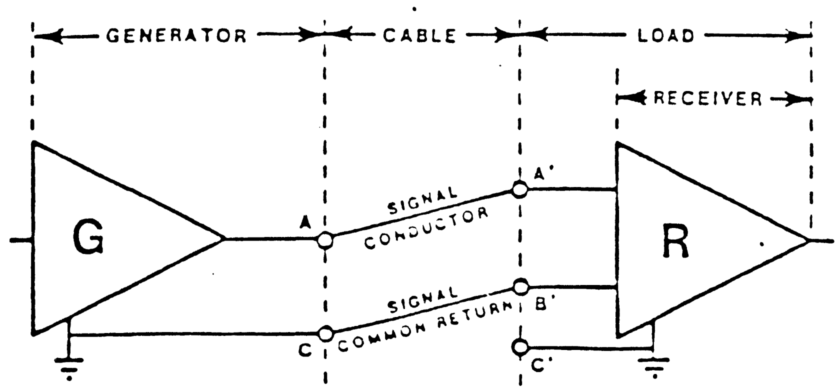


34 PINS (LETTERED)

- Balanced drivers and receivers for data and timing signals



- Unbalanced control circuits



- Electrical Characteristics
  - Balanced
    - binary 0=+.55V 20% (A to B)
    - binary 1-=.55V 20% (A to B)
  - Unbalanced
    - on = +3V to +25V
    - off = -3V to -25V

CIRCUIT FUNCTION	PIN	CCITT/RS-232-C
Protective Ground	A	101/AA
Signal Ground	B	102/AB
Request To Send	C	105/CA
Clear To Send	D	106/CB
Data Set Ready	E	107/CC
Received Line Signal Detector	F	109/CF
Test Mode	K	142/
RX Data A	R	104/BB
RX Data B	T	104/BB
RX Clock A	V	115/DD
RX Clock B	X	115/DD
TX Clock A	Y	114/DB
TX Clock B	AA/a	114/DB
TX Data A	P	103/BA
TX Data B	S	103/BA
External Clock A	U	113/DA
External Clock B	W	113/DA
Remote Loopback	BB/b	140/CG
LL Loopback	J	141/
RT Loopback	EE/f	126/
Test Pattern	L	125/CE

CCITT V.35 interface Categories
and EIA Equivalent Categories

(D) Transistor to Transistor Logic (TTL) Interface

- common interface if modem is located in terminal equipment
- electrical characteristics
  - Mark (1, OFF) = +5V
  - Space (0, ON) =0V
- very high speed
- very short distance (within terminal equipment).

(E) Current Loops

- very simple asynchronous interface for DTE
- used up to 1800 ft. normally; often longer
- originally provided current to drive mechanical teletype machines (18 mA)
- typically now use 20 mA (sometimes 60 mA on old TTY's
  - polar: mark = +20mA, space = -20mA
  - neutral: mark = +20mA, space = 0mA
- active or passive
- usually use optoisolators with DTE logic
- seldom used to interface with DCE (modems)
- serial data transfer at fairly low rates

(F) Universal Asynchronous Receiver Transmitter (UART) and (Universal Synchronous Asynchronous Receiver and Transmitter (USART)

- UART - used for interface to asynchronous DCE's only
- USART - used for interface to synchronous or asynchronous DCE's only
- Central component of DTE to DCE interface
- Converts the internal (parallel) bus data of the DTE to serial synchronous or asynchronous data to be transmitted by a modem
- Converts the serial synchronous or asynchronous data received by a modem to the parallel bus data of the DTE
- Typical features
  - often programmable
  - supplies and checks start, stop, and parity bits
  - clocks data at a preset rate
  - includes numerous control and status lines for DTE
  - may include modem controls (DSR, DTR, CTS, RTS)
  - may handle synchronous protocols

- Normally interfaces to DCE through IC's MC 1488 and MC 1489 - RS232 drivers and receivers intel®

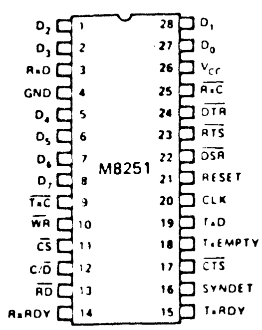
M8251
PROGRAMMABLE COMMUNICATION INTERFACE

MILITARY TEMP.

- Synchronous and Asynchronous Operation
  - Synchronous:
    5-8 Bit Characters
    Internal or External Character Synchronization
    Automatic Sync Insertion
  - Asynchronous:
    5-8 Bit Characters
    Clock Rate — 1, 16 or 64 Times Baud Rate
    Break Character Generation
    1, 1½, or 2 Stop Bits
    False Start Bit Detection
- Baud Rate — DC to 56k Baud (Sync Mode)
  DC to 8.1k Baud (Async Mode)
- Full Duplex, Double Buffered, Transmitter and Receiver
- Error Detection — Parity, Overrun, and Framing
- Fully Compatible with 8080 CPU
- All Inputs and Outputs Are TTL Compatible
- Full Military Temperature Range -55°C to +125°C
- ±10% Power Supply Tolerance

The M8251 is a Universal Synchronous/Asynchronous Receiver/Transmitter (USART) Chip designed for data communications in microcomputer systems. The USART is used as a peripheral device and is programmed by the CPU to operate using virtually any serial data transmission technique presently in use (including IBM Bi-Sync). The USART accepts data characters from the CPU in parallel format and then converts them into a continuous serial data stream for transmission. Simultaneously it can receive serial data streams and convert them into parallel data characters for the CPU. The USART will signal the CPU whenever it can accept a new character for transmission or whenever it has received a character for the CPU. The CPU can read the complete status of the USART at any time. These include data transmission errors and control signals such as SYNDET, TxEMPT. The chip is constructed using N-channel silicon gate technology.

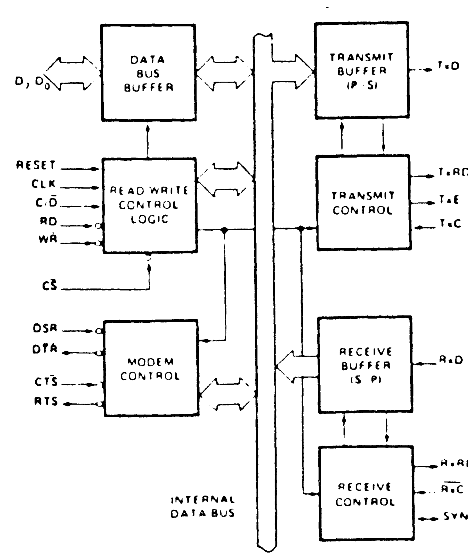
PIN CONFIGURATION



Pin Name	Pin Function
D7-D0	Data Bus (8 bits)
C/D	Control or Data is to be Written or Read
RD	Read Data Command
WR	Write Data or Control Command
CS	Chip Enable
CLK	Clock Pulse (TTL)
RESET	Reset
$\overline{TxC}$	Transmitter Clock
TxD	Transmitter Data
$\overline{RxC}$	Receiver Clock
RxD	Receiver Data
RxRDY	Receiver Ready (has character for 8080)
TxRDY	Transmitter Ready (ready for char. from 8080)

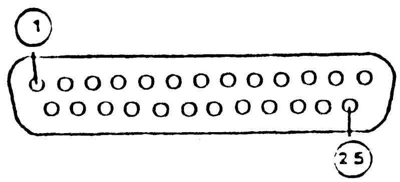
Pin Name	Pin Function
DSR	Data Set Ready
DTR	Data Terminal Ready
SYNDET	Sync Detect
$\overline{RTS}$	Request to Send Data
$\overline{CTS}$	Clear to Send Data
TxE	Transmitter Empty
Vcc	+5 Volt Supply
GND	Ground

M8251 BLOCK DIAGRAM

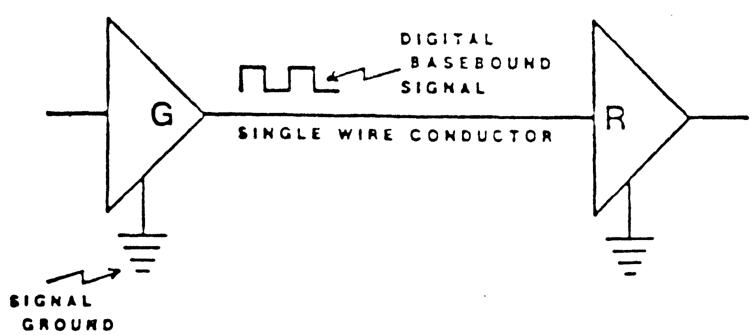


(G) RS366 - EIA Standard Interface used to interface DTE's to 801 Automatic Calling Units.

- 25 pin connector is used for interface



- Define interface leads for data transfer and handshaking information
- Electrical characteristics
  - Mark (OFF, 1) -3V to -25V (normally -12V)
  - Space (ON, 0) +3V to +25V (normally +12V)
- Limited to 50 ft. cable length
- Unbalanced signal thus susceptible to cross talk and noise pick-up
- One wire (single-end) used for each signal with common return (signal ground-pin 7)



RS366 Unbalanced Circuit

- Compatible with CCITT V.25/V.28
  - V.25 - signal description
  - V.28 - electrical characteristics

Pin No.	To DTE	To DCE	Function	Circuit (CCITT)	(EIA)
1			Protective Ground	212	AA
2		-->	Digit Present	211	DPR
3	<--		Abandon Call and Retry	205	ACR
4		-->	Call Request	202	CRQ
5	<--		Present Next Digit	210	PND
6	<--		Power Indication	213	PWI
7			Signal Ground	201	AB
8			Unassigned		
9 & 10			Reserved for Automatic Calling Equipment Testing. These two pins shall not be wired in the data terminal equipment.		
11			Unassigned		
12			Unassigned		
13	<--		Call Origination Status	204	COS
14		-->	Digit Signal Circuits	206	NB1
15		-->	Digit Signal Circuits	207	NB2
16		-->	Digit Signal circuits	208	NB4
17		-->	Digit Signal Circuits	209	NB8
18			Unassigned		
19			Unassigned		
20			Unassigned		
21			Unassigned		
22	<--		Data Line Occupied	203	DLO
23			Unassigned		
24			Unassigned		
25			Unassigned		

EIA RS 366 CCITT V.24-V.25 Interface Connector Pin Assignments

- Circuit Definitions

  - Protective Ground
    EIA Circuit AA (CCITT 212)
    Direction: Not Applicable
    Pin 1

    This conductor shall be electrically bonded to the machine or equipment frame. It may be further connected to external grounds as required by applicable regulations

  - Signal Ground
    EIA Circuit AB (CCITT 201)
    Direction: Not Applicable
    Pin 7

    This conductor establishes the common ground reference potential for all interchange circuits except Circuit AA (Protective Ground). Within the automatic calling equipment, this circuit shall be brought to one point, and it shall be possible to connect this point to Circuit AA by means of a wire strap inside the equipment. This wire strap can be connected or removed during Installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

  - Call Request
    EIA Circuit CRQ (CCITT 202)
    Direction: To Automatic Calling Equipment
    Pin 4

    Signals on this circuit are generated by the data terminal equipment to request the automatic calling equipment to originate a call.

    The ON condition indicates a request to originate a call and must be maintained during call origination, until Circuit COS (Call Origination Status) is turned ON, in order to hold the connection to the communication channel (remain OFF HOOK). The call is aborted if Circuit CRQ is turned OFF prior to turning ON Circuit COS.

    The OFF condition indicates that the data terminal equipment is not using or has completed a prior use of the automatic calling equipment. To avoid a potential race condition, Circuit CD (Data Terminal Ready) (see RS-232-C) in the interface of the associated modem should be turned OFF.

After the automatic calling equipment has turned ON Circuit COS, the data terminal equipment may turn Circuit CRQ OFF without causing a disconnect.

Circuit CRQ must be turned OFF between calls or call attempts and shall not be turned ON unless Circuit DLO (Data Line Occupied) is in the OFF condition.

- Power Indication
  EIA Circuit PWI (CCITT 213)
  Direction: FROM automatic calling equipment
  Pin 6

  Signals on this circuit are generated by automatic calling equipment to indicate whether power is available within the automatic calling equipment.

  The ON condition indicates that power is available in the automatic calling equipment.

  This circuit should not be interpreted to indicate the power status in any other equipment.

- Data Line Occupied
  EIA Circuit DLO (CCITT 203)
  Direction: FROM automatic calling equipment
  Pin 22

  Signals on this circuit are used to indicate when the communication channel is in use for automatic calling, data communication, voice communication, or for testing of the automatic calling or data communication equipment.

  The ON condition indicates that the communication channel is in use.

  The OFF condition indicates that the data terminal equipment may originate a call provided that Circuit PWI (Power Indication) is ON.

  The OFF condition of Circuit DLO shall not be presented until all of the other interchange circuits from the automatic calling equipment are returned to their proper idle condition.

- Call Origination Status
  EIA Circuit COS (CCITT 204*)
  Direction: FROM automatic calling equipment

  NOTE: This circuit was called Circuit DSS (Data Set Status) in earlier versions of EIA RS-366

  *CCITT Circuit 204 (Distant Station Connected) is defined differently but used in a similar manner.

  Signals on this circuit are generated by the automatic calling equipment to indicate the status of automatic call origination procedures.

  The ON condition presented during a call originated by the automatic calling equipment indicates that the automatic calling equipment has completed its call origination functions and that the control of the communication channel has been transferred from Circuit CRQ (Call Request) to circuit CD (Data Terminal Ready) in the data set interface (see RS-232-C). When Circuit COS is turned ON, the data terminal equipment may turn Circuit CRQ OFF without causing a communication channel disconnect. Disconnection of the channel by the data terminal equipment is then possible only through the associated data set interface.

  Once Circuit COS is turned ON, it shall remain ON at least until Circuit CRQ is turned OFF by the data terminal equipment. Circuit COS may come ON at other times, e.g., during an incoming call or a manually originated call. But any ON condition appearing at a time other than during automatic call origination by the automatic calling equipment should be disregarded.

  This circuit should not be interpreted to convey information regarding the operational status or state of preparedness of the associated data set.

- Abandon Call and Retry
  EIA Circuit ACR (CCITT 205)
  Direction: FROM automatic calling equipment
  Pin 3

  Signals on this circuit are used to indicate the probability of successful completion of the call attempt.

The ON condition, when presented during the process of call origination, indicates that there is a high probability that the connection to a remote data station cannot be successfully established and is a suggestion to the data terminal equipment to abandon the call and to re-initiate the call at a later time. The automatic calling equipment does not determine that the call is to be abandoned. Action required to abandon the call must be initiated by the data terminal equipment.

The OFF condition indicates that there is no reason to believe that the call cannot be successfully completed.

When the answer signal mode of operation is used, Circuit ACR remains in the OFF condition after Circuit COS (Call Origination Status) is turned ON. When the End of Number mode is used, Circuit ACR continues to function after Circuit COS is turned ON.

- Digit Signal Circuits (Data Bit 1)
  EIA Circuit NB1 (CCITT 206)
  Pin 14

- Digit Signal Circuits (Data Bit 2)
  EIA Circuit NB2 (CCITT 207)
  Pin 15

- Digit Signal Circuits (Data Bit 3)
  EIA Circuit NB4 (CCITT 208)
  Pin 16

- Digit Signal Circuits (Data Bit 4)
  EIA Circuit NB8 (CCITT 209)
  Pin 17

Direction: TO automatic calling equipment

Parallel binary signals on these circuits are generated by the Data Terminal Equipment.

The information presented on these interchange circuits may either be transmitted (e.g., digits of the called number) or used locally as a control signal. An important use of these interchange circuits for control purposes is the passing of the EON (end of number) code combination to the automatic calling equipment after the last digit of the number to be called has been passed.

In response to EON, the automatic calling equipment transfers the communication channel to the modem immediately without waiting for an answer signal from the called data set.

The character sets provided by the sixteen code combinations are shown in Section 9.2.2.

- Present Next Digit
  EIA Circuit PND (CCITT 210)
  Direction: FROM automatic calling equipment
  Pin 5

  Signals on this circuit are generated by the automatic calling equipment to control the presentation of digits on the Digit Signal Circuits.

  The ON condition indicates that the automatic calling equipment is ready to accept the next digit indicated on Circuits NB1, NB2, and NB8 (Digit Signal Circuits).

  The OFF condition indicates that the data terminal equipment should turn OFF Circuit DPR (Digit Present) and set the states of the Digit Signal Circuits for the next digit. Circuit PND (Present Next Digit) shall not be changed to the ON condition while Circuit DPR is ON.

  Circuit PND may come ON after the data terminal equipment turns Circuit DPR OFF following the presentation of the last code combination on the Digit Signal Circuits.

- Digit Present
  EIA Circuit DPR (CCITT 211)
  Direction: TO automatic calling equipment
  Pin 2

  Signals on this circuit are generated by the data terminal equipment to indicate that the automatic calling equipment may read the code combination presented on the Digit Signal circuits NB1, NB2, NB4, NB8.

  The OFF and ON transition indicates that the data terminal equipment has set the states of the Digit Signal Circuits for the next digit.

Circuit DPR (Digit Present) must not be turned ON before circuit PND (Present Next Digit) comes ON. When turned ON, Circuit DPR must remain ON until Circuit PND goes OFF. Circuit DPR may then be turned OFF, and when turned OFF, must be held OFF until Circuit PND comes on again.

After the automatic calling unit has accepted the last digit of the called number (including EON when used) and has turned Circuit PND OFF, Circuit DPR must be turned OFF and held in the OFF condition even though Circuit PND may come ON again.

10. Telephone Interface

A. Public Switched Telephone Network (PSTN) Plug and Jacks

- The PSTN was previously called the Direct Distance Dialing (DDD) Network. This is the dial-up network that you use in your home or office.

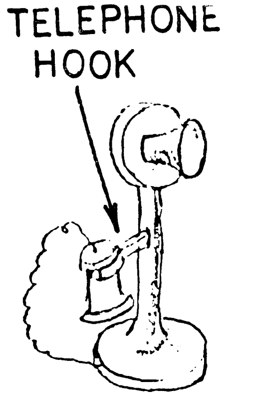
- The interface between the Public Switched Telephone Network (PSTN) and the Data Circuit-Terminating Equipment (DCE) is defined by EIA Standard RS496. This Standard defines the characteristics required by the telephone line and the modem.

- Connection to this interface is regulated by the Federal Communications Commission (FCC). All devices that connect to the PSTN must be registered under FCC Part 68.

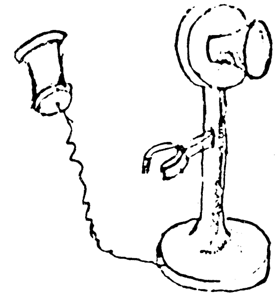
- Before connecting a registered device you should provide the Telephone Company with the FCC Registration number and the Ringer Equivalence Number (REN).

- The REN specifies how much loading (Number of Bells) the Telephone Company Central Office (CO) equipment has when ringing the line. One telephone is equivalent to a REN of one (one Bell). The minimum REN is 0.0. The maximum REN permitted is 5.0. The letter following the REN number specifies the type ringer that the device is designed to work with. Ring types "A" through "Q" may be provided by the telephone. Ringer Type "B" is most common because it is compatible with most other type ringers.

- The FCC Part 68 Universal Service Order Code (USOC) specifies a series of Registered Jacks arrangements (RJXX) that must be used when connecting to the PSTN. The wiring configurations and modes of operation are specified in the USOC.

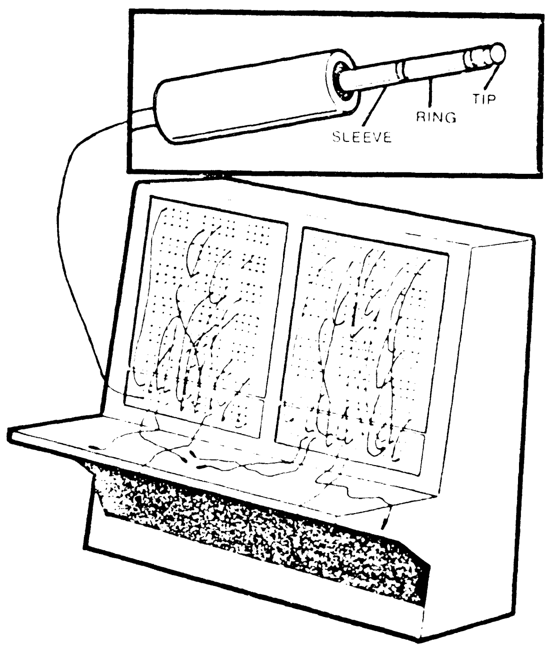


Telephone is "On Hook" - disconnected from the telephone line



Telephone is "Off Hook" - connected to the telephone line

Meaning of Terms "On Hook" and "Off Hook"



Origin of Terms "Tip" and "Ring"

The origin of terms "tip and ring" was the plug used on the old operator patch panel.

<u>Tip</u> - end of patch panel plug. One lead of the analog interface to the telephone line.

<u>Ring</u> - the second contact on operator patch panel plug. The other lead of the analog interface to the telephone line.

<u>Sleeve</u> - the third contact on operator patch panel plug. This lead is often connected to earth ground. On some PBX systems this lead is used for special control functions. On <u>Ground Start</u> local loops the tip lead is momentarily shorted to earth ground to draw dial tone. On <u>Loop Start</u> local loops this lead is not used. Dial tone is started by putting 600 ohms impedence between "tip" and "ring". Most modems are designed to operate on loop start circuits.

(1) Permissive (Voice Jacks)

- Permits a fixed level of transmitted signal no greater than -9dBm.

- Does not guarantee the signal level at the Central Office (CO). The optimum CO signal is -12dBm.
- The normal line loss between the customer and the CO is 3dB to 6dB. Thus, the level received at the CO will normally be between -12dBm and -15dBm.

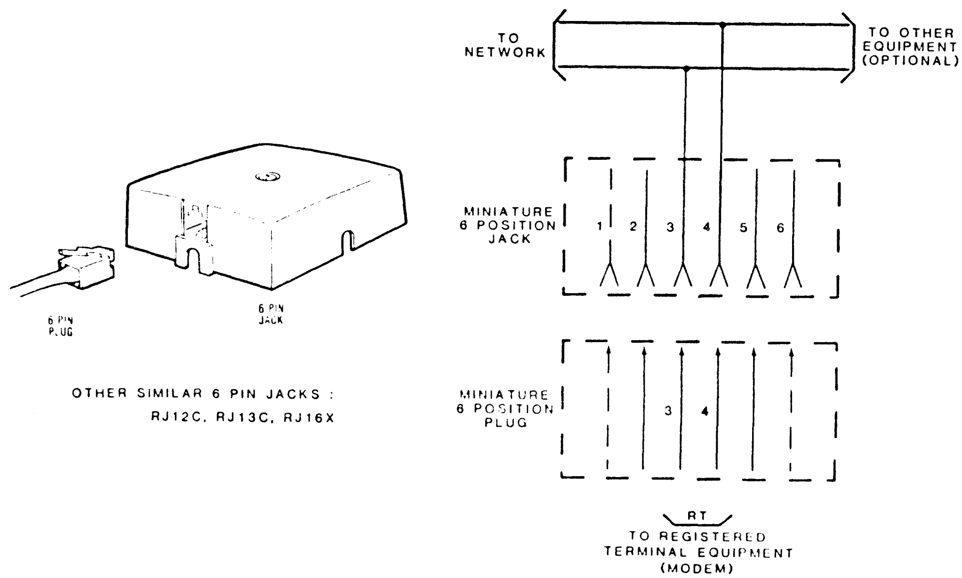
- A permissive jack arrangement is typically sufficient for most modem applications.

- If problems are experienced with the permissive telephone line characteristics, the Telephone Company will be very reluctant to fix the problems. This is because a permissive line is defined as a voice grade line. If you can talk on it, it is within specifications.

- Parameter such as attenuation distortion, envelope delay distortion, line loss, signal to noise ratio, and P/AR are not guaranteed on a permissive arrangement.

- If telephone line problems are experienced on a permissive arrangement a data jack arrangement may have to be ordered to resolve the problems.

• RJ11C - most common permissive arrangement. Normally found in home or office.



RJ11C PERMISSIVE JACK

- 6-pin modular jack for single line bridged tip and ring connection.

- Only two wires are used, tip and ring.

- RJ12C and RJ13C are special permissive arrangements that are associated with multi-line key telephones. Four wires are used in the RJ12 and RJ13. CAUTION should be used when connecting a modem into the arrangements. In most cases, the modem/key telephone will not operate properly behind an RJ12 and RJ13 without having a transfer key installed by the Telephone Company.

- RJ16X is a special permissive arrangement that permits the use of an exclusion key telephone.

(2) Data Jacks

- Provide a means of adjusting the signal level that is received at the CO. There are two methods of adjusting the CO signal level: Programmable and Fixed Loss Loop.

- Programmable Arrangement - the modems output level is adjusted with a Telephone Company selected programming resistor.

  - Resistor is located internal to the Data Jack.
  - Telephone Company measures the local loss loop at the time of installation and selects a resistor value, such that the transmitted signal arrives at the CO at the optimum signal power level of -12dBm.
  - A table of resistor values used for implementing the automatic control of signal power output is provided in FCC Part 68.
  - The Telephone Company can adjust for the optimum level without having the modem connected.

- Fixed Loss Loop (FLL) Arrangements - the modems output level is fixed at a signal level of -4dBm. A Telephone Company adjustable attenuator is installed in series with modem to compensate for local loop loss.

  - The attenuator is installed or adjusted by the Telephone company at the time of installation.

  - The attenuator is located in the Data Jack.

  - The telephone adjusts the attenuator to have an optimum power level of -12dBm at the CO.

  - UDS modems are not designed to work into a Fixed Loss Loop Arrangement.

- Bell Operating Companies (BOC) have specified parameters for local loop characteristics when a Data Jack is used.

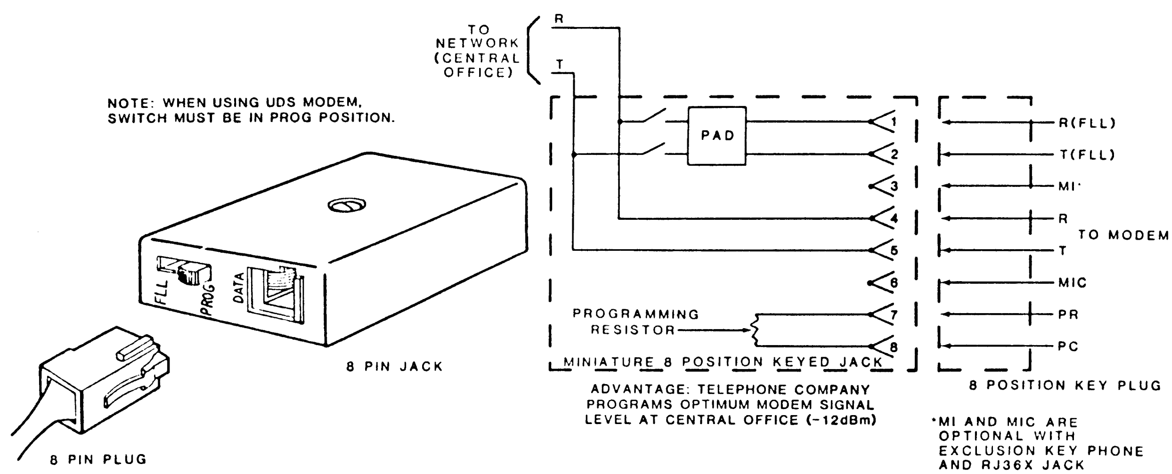
- Specifications such as attenuation distortion, envelope delay distortion, line loss, signal to noise ratio, and P/AR are guaranteed on a Data Jack.

- The Telephone Company is more likely to fix telephone line problems when you have a Data Jack.

- A Data Jack will cost a little more at installation, but the monthly tariff is normally the same as the permissive jack.

. Two categories of Data Jack configurations: "Universal" RJ41S(97A) and "Programmed" RJ45S(97B).

. "Universal" RJ41S(97A)



RJ41S
UNIVERSAL
(PROGRAMMABLE/FIXED LOSS LOOP)
JACK

- 8 Pin modular Jack

- Attenuation (PAD) across FLL tip (pin 1) and ring (pin 2) are leads for Fixed Loss Loop (FLL) transmitted signal level.

- When using UDS modem the switch must be placed in the PROG position. If the switch is placed in the FLL position, both the received and transmitted signals will be attenuated. This may cause a higher than normal error rate.

- The Mode Indication (MI) (pin 3) and Mode Indication Common (MIC) (pin 6) leads are for connection to an exclusion key telephone if used.

- The tip (pin 5) and ring (pin 4) leads to the modem are used for connection to the telephone line when the PROG switch position is selected.

- The programming resistor across Programmed Resistor (PR) (pin 7) and Programmed Resistor Common (PC) (pin 8) leads are for a programmed output level when in the PROG switch position.

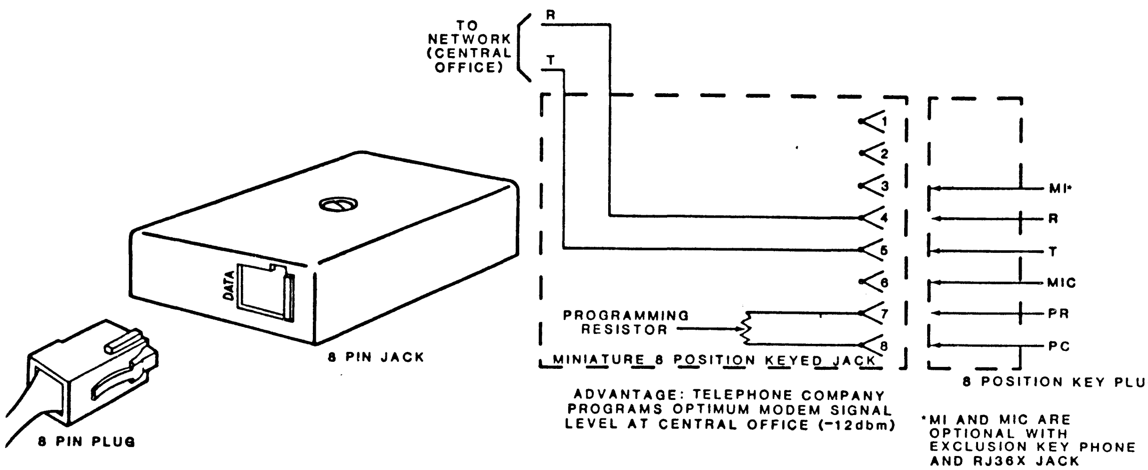
<u>Programming</u> <u>Resistor</u> (Rp)*	Programmed Data Equipment <u>Signal</u> <u>Power</u> <u>Output</u>**
short	0 dbm
150 ohms	-1 dbm
336 ohms	-2 dbm
569 ohms	-3 dbm
866 ohms	-4 dbm
1,240 ohms	-5 dbm
1,780 ohms	-6 dbm
2,520 ohms	-7 dbm
3,610 ohms	-8 dbm
5,490 ohms	-9 dbm
9,200 ohms	-10 dbm
19,800 ohms	-11 dbm
open	-12 dbm

* Tolerance of Rp is ± 1%

** Tolerance of programmed data equipment signal power output is ± 1 dB

Table of Programming Resistor Values

• "Programmed" RJ45S(97B)



RJ45S
PROGRAMMABLE JACK

- 8 pin modular jack

- Mode Indication (MI) (pin 3) and Mode Indication Common (MIC) (pin 6) leads are for connection to an exclusion key telephone if used.

- Tip (pin 5) and ring (pin 4) leads are used for connecting the modem to the telephone line.

- FLL tip (pin 1) and ring (pin 2) are not used.

- Programming Resistor across PR (pin 7) and PC (pin 8) are for a programmed output level.

- Programming resistor values are the same as those specified for the RJ41S arrangement.

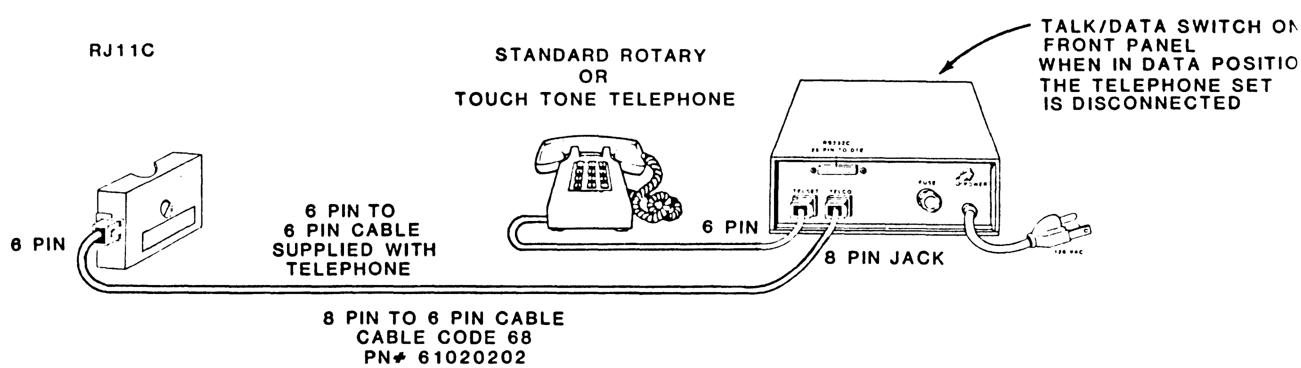
(3) Typical Modem Connection

(A) Connection of a Standalone modem to a permissive RJ11C Jack.

- Use 8 pin to 6 pin modular jack cable (UDS cable code 68, part number 61020202) between the Telco Jack (8 pin) on the rear of the modem and the RJ11C (6 pin) Jack on the wall.

- A standard rotary or touch tone telephone should be connected into the telset Jack on the rear of the modem. The cable that comes with the telephone should be used for this connection.

- A Talk/Data switch on the front panel is used to connect the telephone line to the modem or the telephone. This switch should be placed in the data position to permit automatic answering of calls.



TYPICAL STANDALONE MODEM CONNECTION
FOR PERMISSIVE RJ11C ARRANGEMENT

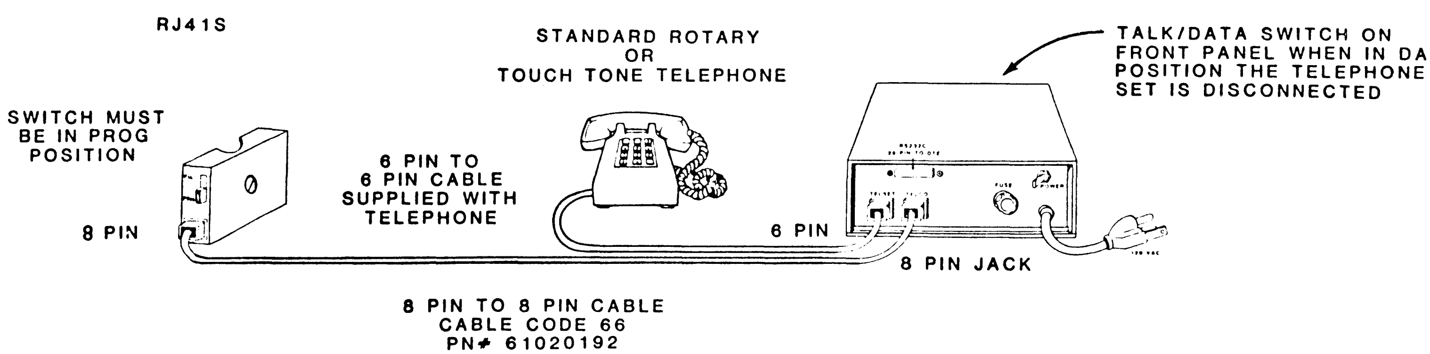
(B) Connection of a Standalone modem to a Data Jack (RJ41S or RJ45S)

- Use 8 pin to 8 pin modular jack cable (UDS cable code 68, part number 61020192) between the Telco Jack (8 pin) on the rear of the modem and the RJ41S or RJ45S (8 pin) jack on the wall.

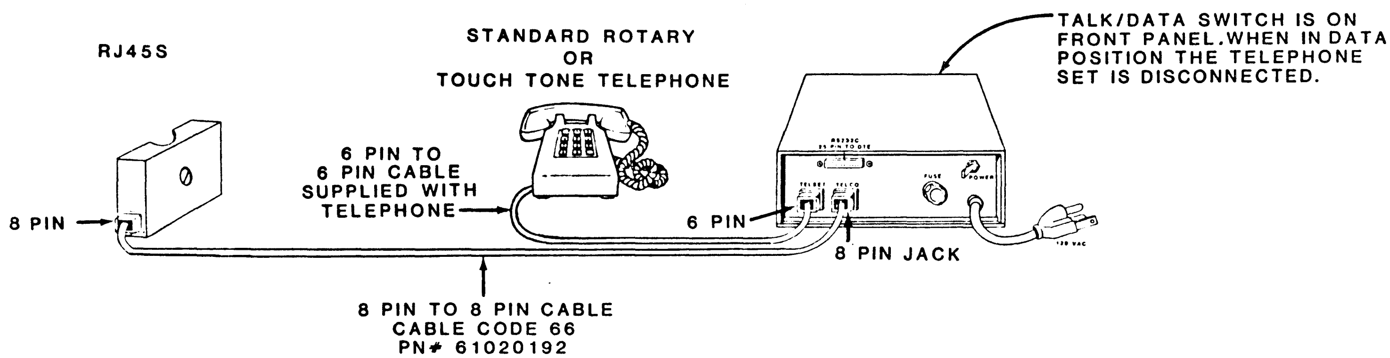
- If the RJ41S jack is used, be sure the switch is placed in the PROG position. UDS modems are <u>not</u> designed to work in the FLL position.

- A standard rotary or touch tone telephone should be connected into the telset jack on the rear of the modem. The cable that comes with the telephone should be used for this connection.

- A Talk/Data switch on the front panel is used to connect the telephone line to the modem or the telephone. This switch should be placed in the data position to permit automatic answering of calls.



TYPICAL STANDALONE MODEM CONNECTION
FOR UNIVERSAL RJ41S ARRANGEMENT



TYPICAL STANDALONE MODEM CONNECTION
FOR PROGRAMMABLE RJ45S ARRANGEMENT

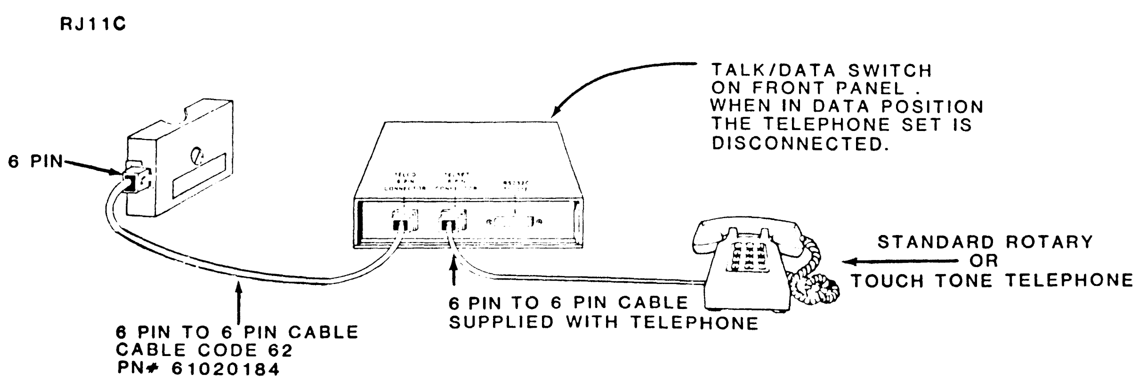
(C) Connection of an LP (Line Powered) modem to a permissive RJ11C Jack.

- Use 6 pin to 6 pin modular jack cable (UDS cable code 62, part number 61020184) between the Telco jack (6 pin) on the rear of the modem and the RJ11C (6 pin) jack on the wall.

- A standard rotary or touch tone telephone should be connected into the Telset jack on the rear of the modem. The cable that comes with the telephone should be used for this connection. If two UDS or two Telephone Company cables are used, the tip and ring leads will be reversed. This may cause problems with some types of touch tone telephones (cannot break dial tone).

- A Talk/Data switch on the front panel is used to connect the telephone line to the modem or the telephone. This switch should be placed in the data position to permit automatic answering of calls.

- The LP series of modems was designed for operation with a permissive arrangement only.



TYPICAL LP SERIES MODEM CONNECTION FOR PERMISSIVE RJ11C ARRANGEMENT

(D) Special modem connection for use with Exclusion Key Telephones.

- Exclusion Key Telephone is a special type of telephone with a white switch hook button on the left hand side that may be lifted up.

- The special switch hook button controls the connection of the tip and ring leads. Also, it controls the opening or shorting of the mode indication (MI/A) and mode indication common (MIC/A1) leads.

- There are two types of Exclusion Key Telephone configurations: "Data set controls the (telephone) line" and "Telephone set controls the (telephone) line."

- Data Set Controls the Line

  - There are three positions for the telephone handsets:

    1. Handset in the cradle
    2. Handset lifted with exclusion in middle position aural monitoring
    3. Handset lifted with exclusion key up

  - Aural Monitoring - permits monitoring of modems analog signal by bridging the tip and ring leads through a capacitor to the ear piece of the handset.

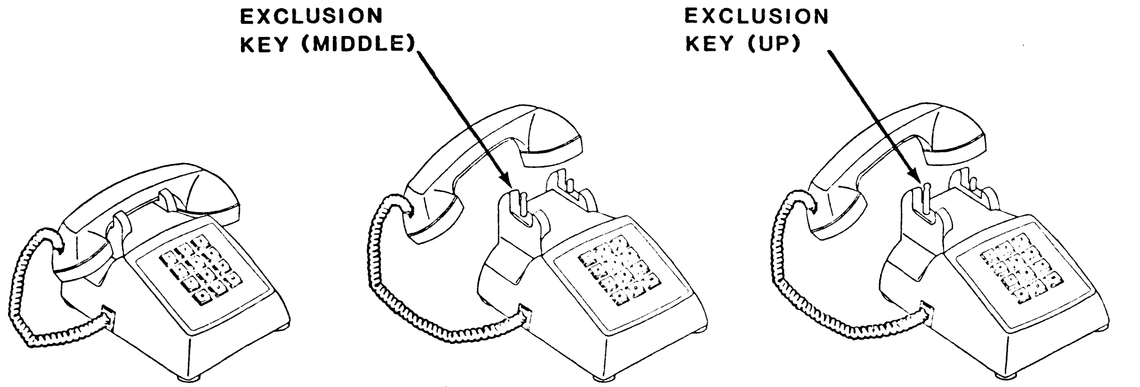
  - With handset in the cradle, the tip and ring leads are passed through the telephone to the modem. The MI(A) and MIC(A1) are open. Incoming calls are routed directly to the modem.

  - With the handset not in the cradle and the exclusion key in the middle position, the tip and ring leads are passed through the modem.

The MI(A) and MIC(A1) leads are open. If optioned for aural monitoring, tip and ring are bridged to the telephone ear piece of the handset through a capacitor

- With the handset not in the cradle and the Exclusion Key pulled up, the tip and ring leads are connected to the handset instead of the modem. The MI(A) and MIC(A1) leads are shorted (tells modem telephone is in voice mode). In this position calls may be manually placed or answered.

- After the call is manually placed or answered, the handset is normally placed in the cradle. This causes the MI(A) and MIC(A1) leads to go from shorted state to an open state. This transition from shorted to open causes the modem to go "Off Hook" and connect to the telephone line.



POSITION 1:
HANDSET IN THE CRADLE AND EXCLUSION KEY DOWN. TIP AND RING ARE PASSED THROUGH TO THE MODEM, AND MI (A) AND MIC (AI) ARE OPEN.

POSITION 2:
HANDSET NOT IN THE CRADLE AND EXCLUSION KEY IN MIDDLE POSITION-AURAL MONITORING. TIP AND RING PASS THROUGH TO THE MODEM. TIP AND RING BRIDGE THROUGH CAPACITOR TO HANDSET AND MI (A) AND MIC (AI) ARE OPEN.

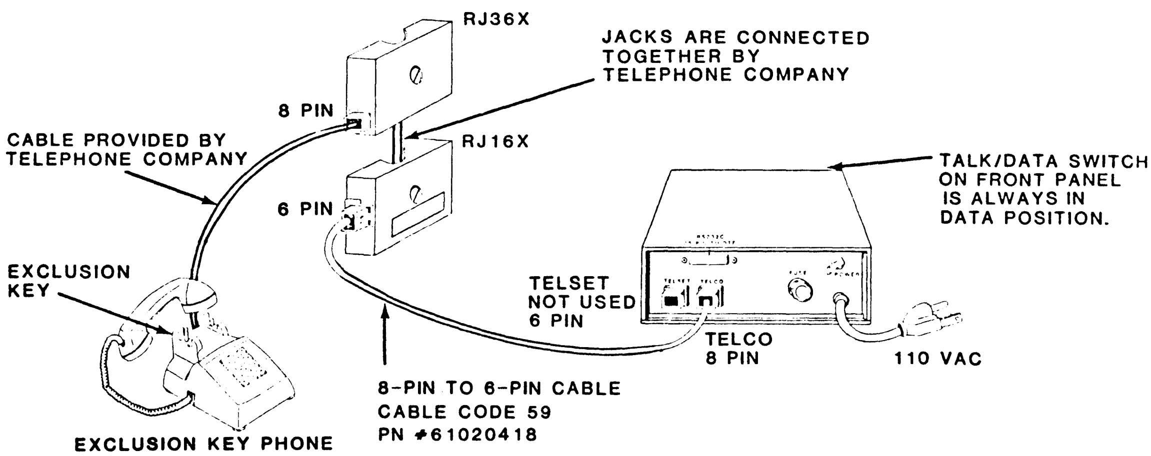
POSITION 3:
HANDSET NOT IN CRADLE AND EXCLUSION KEY IN UPWARD POSITION-MANUALLY PLACE OR ANSWER CALLS. TIP AND RING CONNECTED TO HANDSET AND MI (A) AND MIC (AI) SHORTED.

Three Positions of Exclusion Key Telephone When Wired for "Data Set Controls the Line"

- Connection of a Standalone modem to a permissive RJ16X Jack through an Exclusion Key Telephone.
  - Use 8 pin to 6 pin modular jack cable (UDS Cable Code 59, part number 61020418) between the Teleco Jack (8 pin) on the rear of the modem and the RJ16X (6 pin) jack on the wall.
  - The telset jack on the rear of the modem is not normally used.
  - The Exclusion Key Telephone will be connected to the RJ36X (8 pin) jack. This cable will be provided by the Telephone Company.
- The RJ36X and RJ16X Jacks are connected together by the Telephone Company.

- The modems Talk/Data switch on the front panel should remain in the data position when originating or answering calls.

- LP (Line Powered) modems will not operate with an Exclusion Key Telephone.



Typical Standalone Modem Connection for Permissive RJ16 Arrangement, RJ36 Series Jack and Exclusion Key Telephone (Wired for "Data Set Controls the Line")

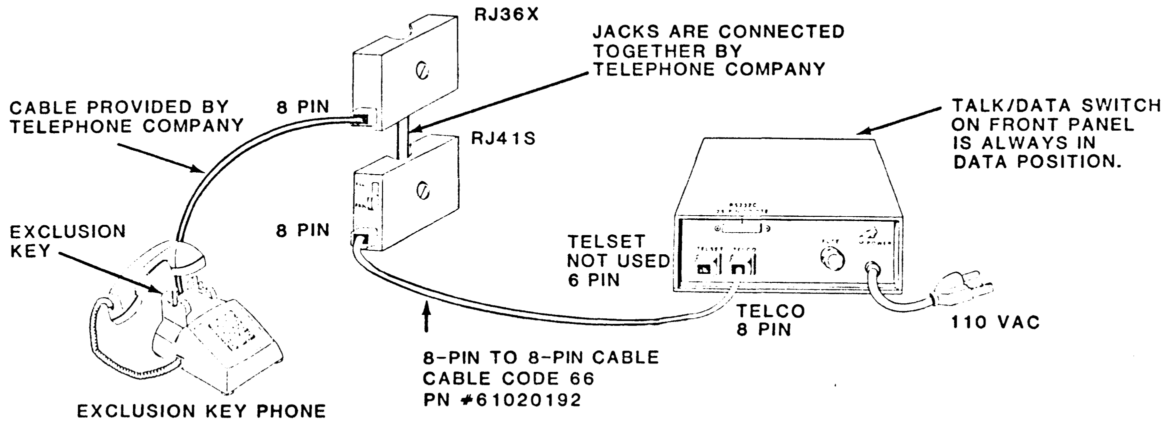
- Connection of a Standalone modem to a RJ41S or RJ45S Data Jack through an Exclusion Key Telephone.

  - Use 8 pin to 8 pin modular Jack cable (UDS Cable Code 66, part number 61020192).

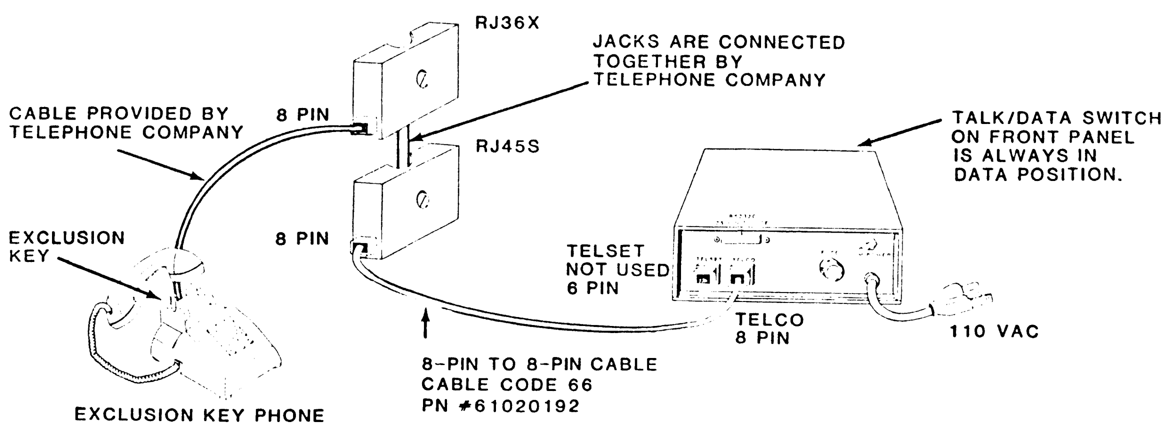
  - Telset Jack on the rear of the modem is not normally used.

  - The Exclusion Key Telephone will be connected to the RJ36X (8 pin) Jack. This cable will be provided by the Telephone Company.

- The RJ36X and RJ41S or RJ45S Jacks are connected together by the Telephone Company.
- The modem Talk/Data switch on the front panel should remain in the data position when originating or answering calls.
- If the RJ41S Jack is used, be sure the switch is placed in the PROG position.

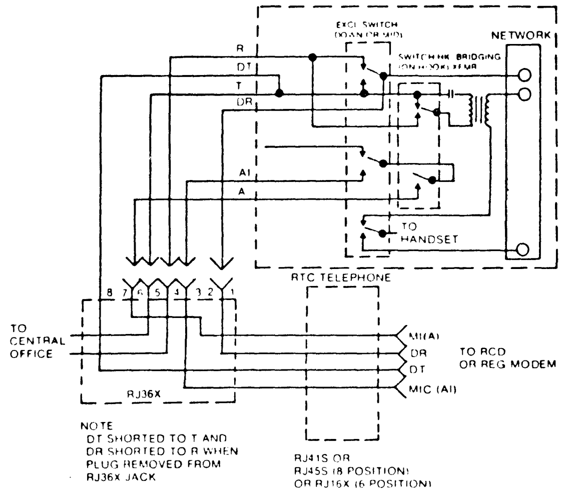


TYPICAL STANDALONE MODEM CONNECTION
FOR UNIVERSAL RJ41S ARRANGEMENT
RJ36X SERIES JACK AND EXCLUSION KEY TELEPHONE
(WIRED FOR "DATA SET CONTROLS THE LINE")



TYPICAL STANDALONE MODEM CONNECTION
FOR PROGRAMABLE RJ45S ARRANGEMENT.
RJ36X SERIES JACK AND EXCLUSION KEY TELEPHONE
(WIRED FOR "DATA SET CONTROLS THE LINE")

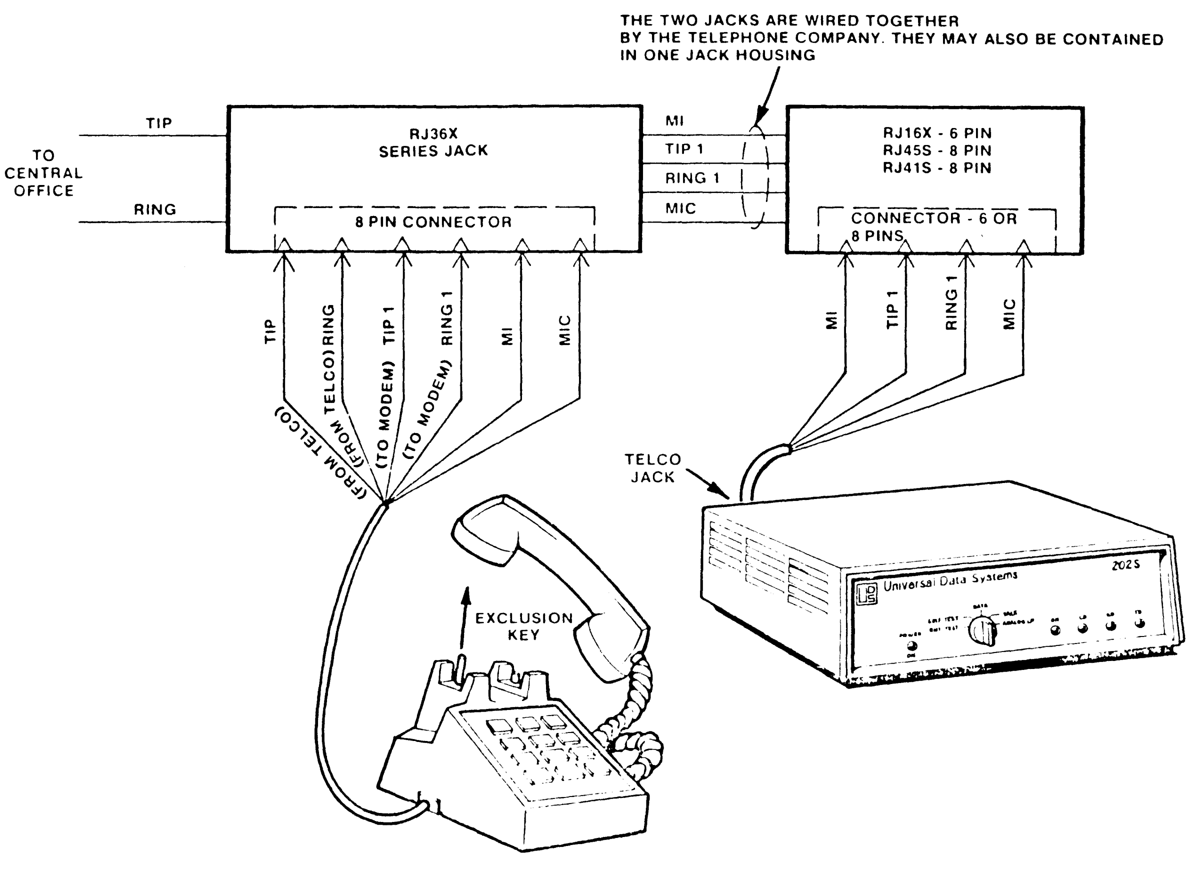
The following figure shows the schematic for the "Data Set Controls the Line" Exclusion Key Telephone. Also a block diagram of an Exclusion Key Telephone setup is provided.



SWITCH POS	ON-HOOK	OFF-HOOK	EXCL SWITCH PULLED UP
MODE	DATA	DATA	VOICE
MI MIC	OPEN	OPEN	CLOSED

NOTE
IN THIS CONFIGURATION THE MODEM HAS CONTROL OF THE LINE. THE EXCLUSION SWITCH MUST BE PULLED FOR VOICE MODE (MANUAL ORIGINATION OF CALL) CALL IS AUTOMATICALLY ANSWERED

Schematic Diagram for a "Data Set Controls the Line" Exclusion Key Telephone



BLOCK DIAGRAM EXCLUSION KEY TELEPHONE INTERCONNECTION

- Telephone Set Controls the Line

  - This configuration is seldom used with direct connect modems. It is normally used with manual answer CDT Data Access Arrangement (DAA).

  - There are three positions for the telephone handset.
    1. Handset in the cradle.
    2. Handset lifted with Exclusion Key in middle position.
    3. Handset lifted with Exclusion Key up.

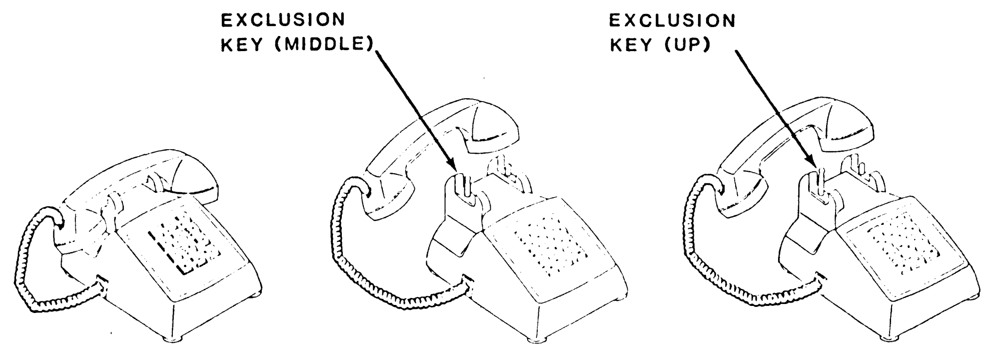
  - Aural monitoring is not available with this type of arrangement.

  - With the handset in the cradle, the tip and ring are connected to the telephone. The MI(A) and MIC(A1) are open. Telephone operates as a normal telephone.

  - With the handset lifted with Exclusion Key in middle position, the tip and ring leads are connected to the telephone handset. The MI(A) and MIC(A1) leads are shorted (telling the modem the telephone is in voice mode). Calls may be manually placed or answered in this position.

  - With the handset not in the cradle and the Exclusion Key pulled up, the tip and ring leads are passed through to the modem. MI(A) and MIC(A1) leads are open.

- Pulling the Exclusion Key to the upward state causes the MI(A) and MIC(A1) leads to go from short to open. This causes the modem to go Off Hook (Data Mode) and connect to the telephone line.



POSITION 1:

HANDSET IN THE CRADLE AND EXCLUSION KEY DOWN. TIP AND RING ARE CONNECTED TO THE TELEPHONE. MI (A) AND MIC (A1) ARE OPEN. VOICE IS DISCONNECTED.

POSITION 2:

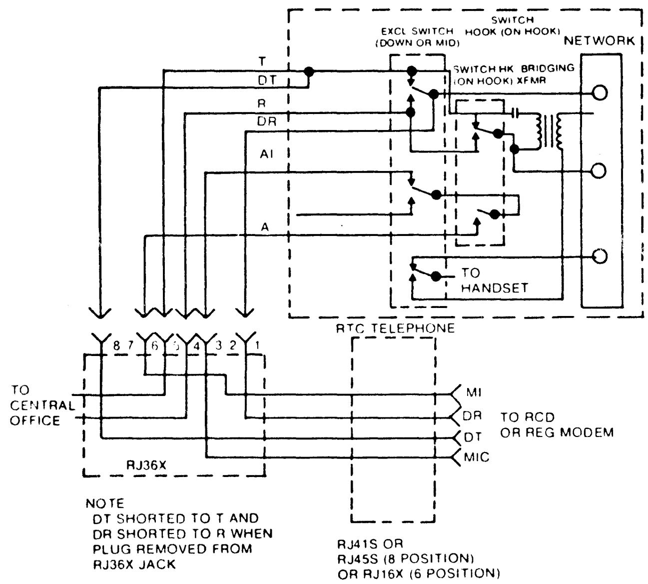
HANDSET NOT IN THE CRADLE AND EXCLUSION KEY IN MIDDLE POSITION - VOICE MODE. TIP AND RING ARE CONNECTED TO THE TELEPHONE HANDSET. MI (A) AND MIC (A1) ARE SHORTED. MANUALLY PLACE OR ANSWER CALLS.

POSITION 3:

HANDSET NOT IN CRADLE AND EXCLUSION KEY IN UPWARD POSITION - DATA MODE. TIP AND RING ARE PASSED THROUGH TO THE MODEM. MI (A) AND MIC (A1) ARE OPEN.

Three Positions of Exclusion Key Telephone When Wired for "Telset Controls the Line"

- To connect a Standalone modem to a "permissive" RJ16X, "Programmable" RJ45S, or a "Universal" RJ41S with an Exclusion Key Telephone wired for "Telephone Set Controls the Line," follow the connection diagrams for "Data Set Controls the Line."



SWITCH POS	ON-HOOK	OFF-HOOK	EXCL SWITCH PULLED UP
MODE	VOICE-DISCONNECTED	VOICE	DATA
MI/MIC	OPEN	CLOSED	OPEN

NOTE
IN THIS CONFIGURATION THE TELEPHONE SET IS IN CONTROL OF THE LINE THE EXCLUSION SWITCH MUST BE PULLED FOR DATA MODE CALL IS TO BE MANUALLY ANSWERED

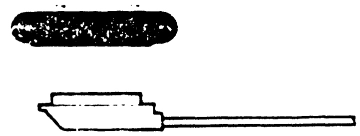
SCHEMATIC DIAGRAM FOR "TELSET CONTROLS THE LINE" EXCLUSION KEY TELEPHONE

When an Exclusion Key Telephone is ordered from the Telephone Company or the Phone Center, the following options must be specified.

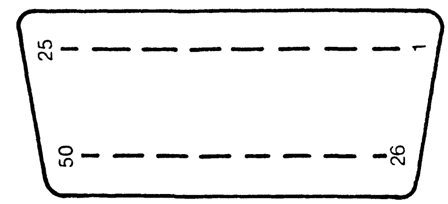
Option Number	Option Name	Option Description	Normally Selected
A1	Telephone Set Controls the Line	Calls must be manually placed and answered with the Exclusion Key Telephone	
A2	Data Set Controls the Line	Calls may be automatically answered by the modem and manually placed with the Exclusion Key Telephone	X
B3	Aural Monitoring not Provided	Does not permit monitoring of modems Analog Signal thru the Telephone Handset	
B4	Aural Monitoring Provided	Permits monitoring of modems Analog Signal through the Telephone Handset	X
C5	DTMF Dialing	Dual Tone Multi-Frequency dialing (Touch Tone)	X
C6	Rotary Dialing	Rotary or Pulse type dialing	
D7	Switch Hook Indication only	Provides indication of position of switch hook (handset), On Hook (in cradle) or Off Hook (out of cradle)	
D8	Voice Mode Indication	Provides indication of Exclusion Key Position. Indicates "Data Mode" as MI and MIC open and "Voice Mode" as MI and MIC shorted	X

EXCLUSION KEY TELEPHONE OPTIONS

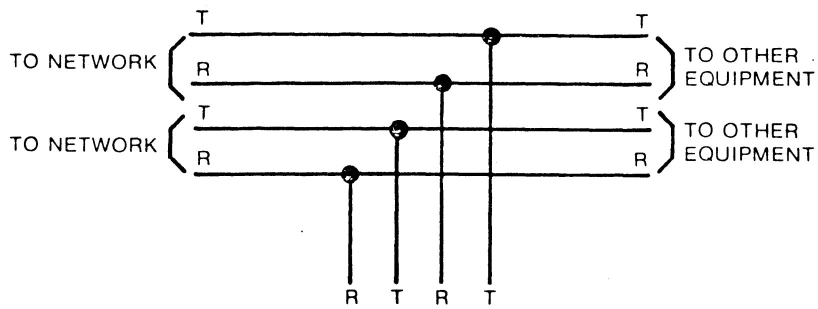
(4) Special Multi-Line Registered Jack Connections
(A) RJ21X Permissive Jack Arrangement



50 PIN



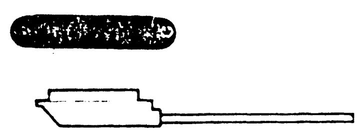
50 POSITION
MINIATURE
RIBBON
JACK



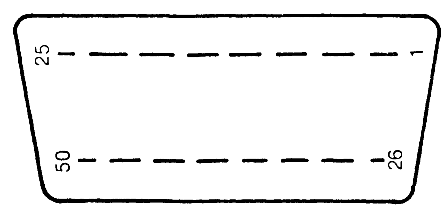
POSITION

LINE	TIP	RING
1	26	1
2	27	2
3	28	3
•	•	•
•	•	•
•	•	•
25	50	25

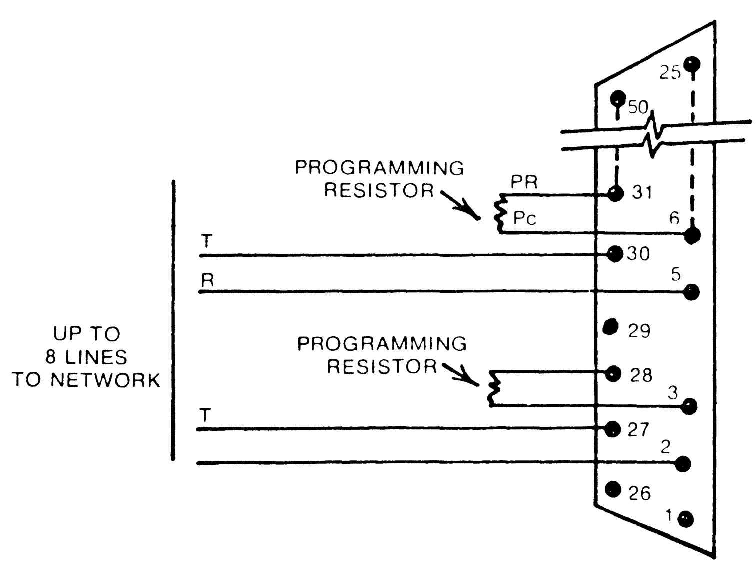
(B) RJ27 Programmable Jack Arrangement



50 PIN



50 POSITION
MINIATURE
RIBBON
JACK



POSITION

LINE	T	R	PR	PC
1	27	2	28	3
2	30	5	31	6
3	33	8	34	9
4	36	11	37	12
5	39	14	40	15
6	42	17	43	18
7	45	20	46	21
8	48	23	49	24

(5) Connection of modems to a multi-line key telephone system.

- Most modems were not designed to work behind multi-line key telephone systems.

- There is very little standardization between multi-line key telephone systems.

- This is the kind of phone system most often found at a secretary desk, where she may answer calls on multiple telphone lines.

- The most common multi-line Key Telephone System is the 1A2 system.

- Multi-line Key Telephone is normally connected through a 50 pin miniature ribbon connector. This connector is similar to that used with the RJ21X and RJ27X Jacks. But, the wiring is not required to conform to these Registered Jacks.

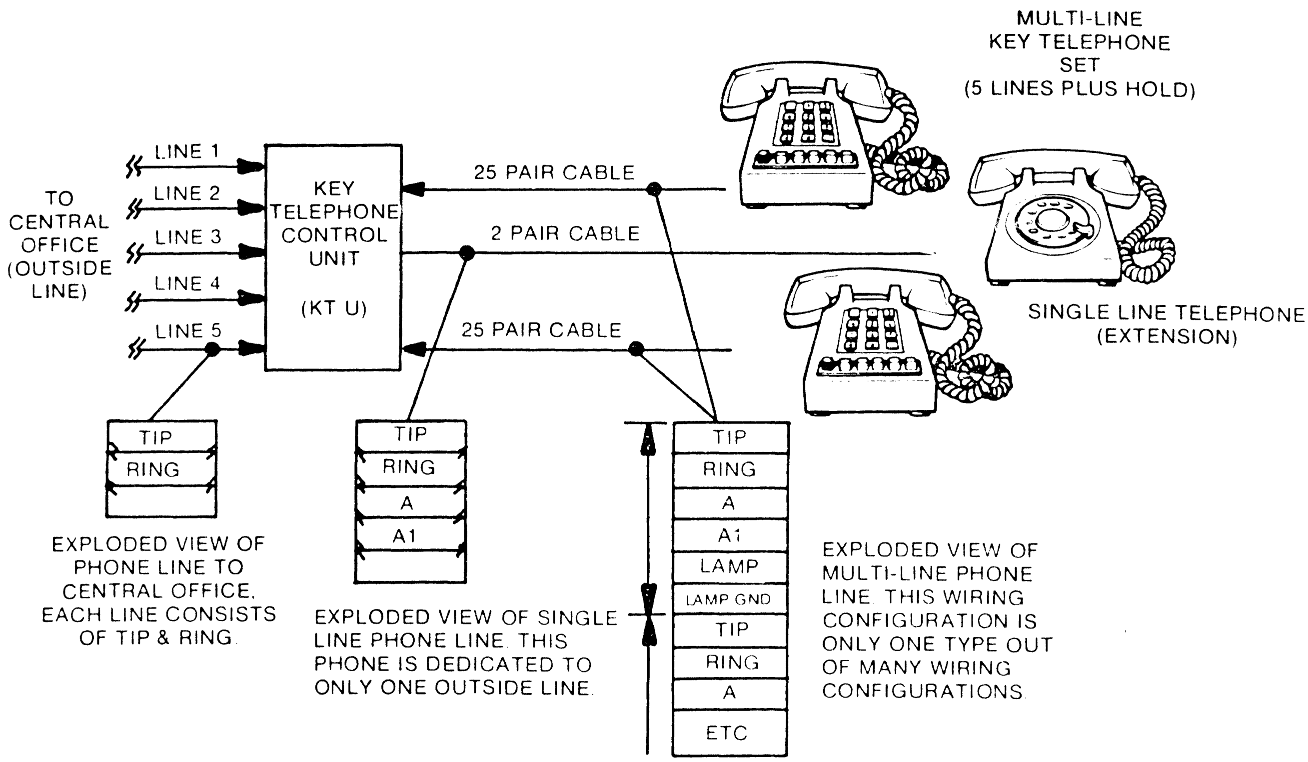
- All Telephones in the system are connected through a centrally located (PBX room) Key Telephone Control Unit (KTU). The purpose of the KTU is to control the status of incoming calls (on line or hold).

- The KTU determines the status of each line by monitoring the A and A1 leads, and the tip and ring leads.

- If A and A1 are shorted and tip and ring have current flowing in them, the line is occupied. Thus, a voltage is placed on the lamp and lamp ground leads to light the light on the multi-line key telephone to indicate that the line is occupied.

- If A and A1 are shorted and tip and ring do not have current flowing in them, the line is on hold. Thus, pulsating voltage is placed on the lamp and lamp ground lead to flash the light on the multi-line key telephone.

- If A and A1 are open and tip and ring do not have current flowing in them, the line is not occupied. Thus, all voltage is removed from the lamp and lamp ground leads. This causes the light to be out.



Typical Configuration of Multi-Line Key Telephone (1A2) System with Interconnect Cabling Shown

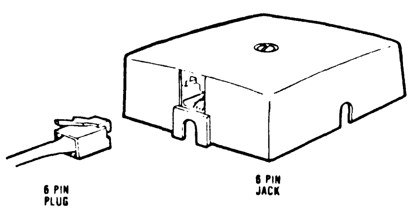
- Single line extensions are often connected through RJ12C or RJ13C Jack.

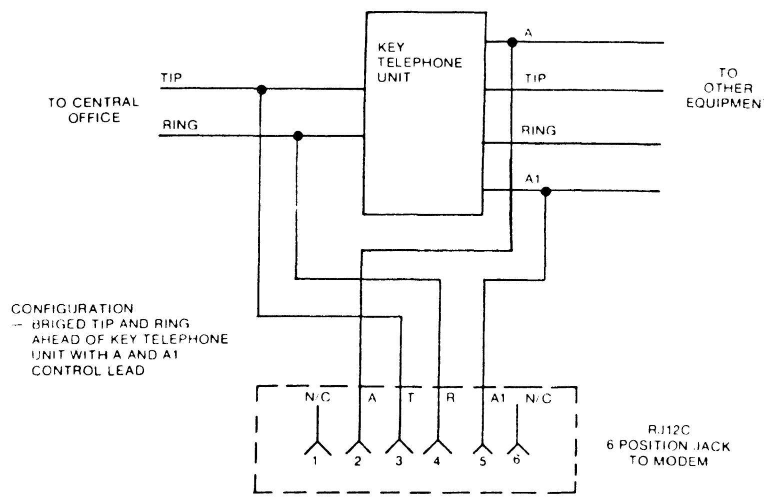
- The RJ12C Jack provides connection of a single line extension through a 6 pin modular Jack (similar to RJ11C permissive arrangement). The tip and ring leads are connected ahead of the KTU (on the CO side). A and A1 leads are connected into the KTU to indicate status of the telephone line.

- The UDS auto answer LP modems provide contact closer on the A and A1 leads. Thus, the auto answer LP modems may be used with this arrangement.

. UDS Manual Answer LP modems pass the A and A1 lead through to the telset Jack. Thus, the telephone must be left Off Hook after going to data mode to prevent going into hold.

. Standalone UDS modems use the A(MI) and A1(MIC) leads as input from an Exclusion Key Telephone. Thus, the modem will not provide the proper closure on these leads for status indication. Since the modem is drawing current on tip and ring, and A(MI) and A1(MIC) are not shorted (inputs to modem), the system may go into hold. This will cause the modem to have a very high error rate.



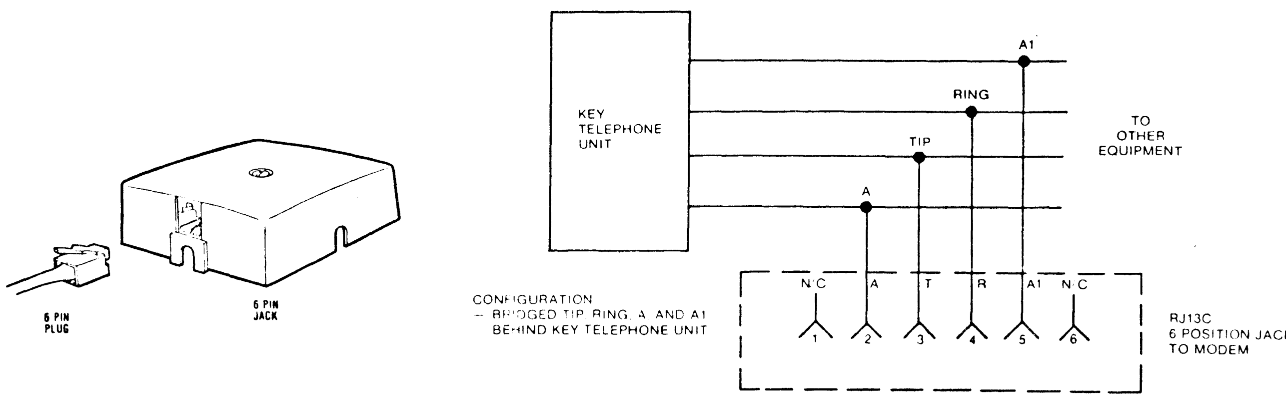


RJ12 Jack Arrangement

. The RJ13C Jack provides connection of a single line extension through a 6 pin modular Jack (similar to the RJ11C permissive arrangement). Tip and ring leads are connected behind the KTU (on the telephone line side). A and A1 leads are connected into the KTU to indicate status of the telephone line.

. The UDS LP modems will operate the same as with the RJ12C jack.

- The UDS Standalone modems will not operate with the RJ13C Jack for the same reasons that it wont operate with the RJ12C.

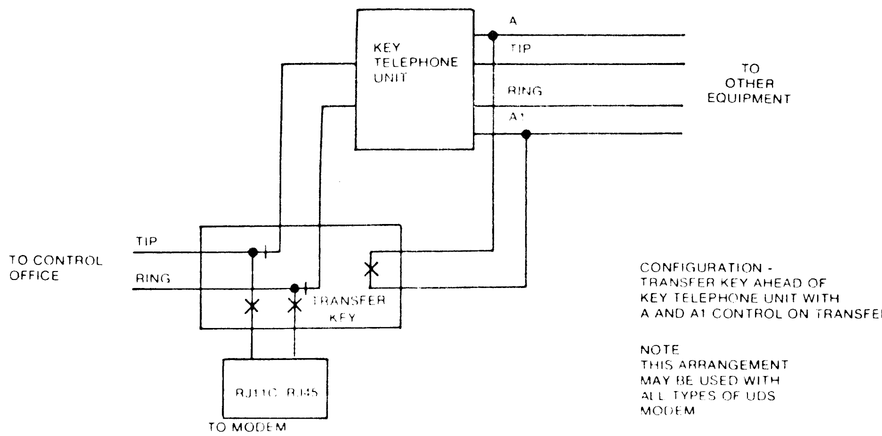


RJ13C Jack Arrangement

- There are many different styles of adapters that are manufactured by many different companies. Most of these adapters connect between the 50 pin Jack on the wall and the 50 pin plug for the multi-line key telephone. Most types of modems will not operate with the adapters, because of the many different wiring configurations and the same problems encountered with the RJ12C and RJ13C.

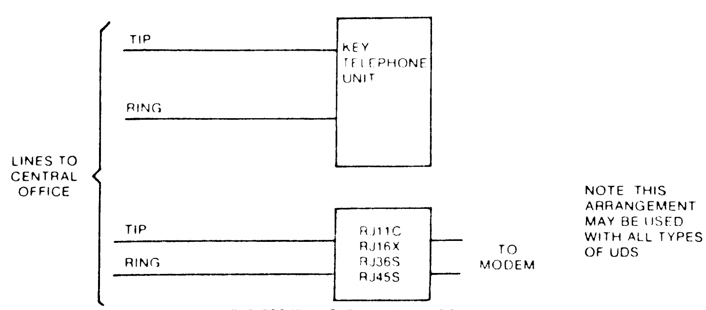
- A Standalone or LP modem <u>may</u> <u>be</u> conencted behind a multi-line key telephone system with a <u>transfer</u> <u>key</u>.

- The <u>transfer</u> <u>key</u> is a specially wired Jack arrangement that may be installed by the Telephone Company. The transfer key is a switch that is connected ahead of the KTU. The switch has two positions: modem and key telephone system. In the <u>modem position</u>, the tip and ring lead are connected to the modem, and the A and A1 leads are shorted to the KTU. In the <u>KTU position</u>, the tip and ring leads are connected to the KTU, and the A and A1 leads are open.



TRANSFER KEY ARRANGEMENT.

- The best and most reliable method is to provide a separate outside line for the modem connection.

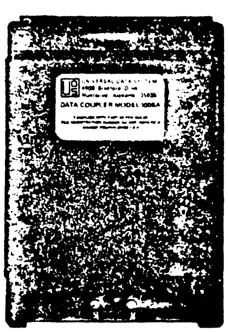


SEPARATE LINE FOR MODEM.

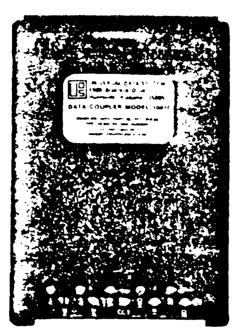
- There are many new types of multi-line/PBX phone systems that are manufactured by many different companies. There is very little, if any, standardization of the wiring configurations for these systems. Many of the systems use digital signaling to select telephones. Other systems are totally digital. Caution should be used when trying to connect a modem behind these phone systems. Connecting a modem behind one of these systems, even though it may use a 6 pin modular Jack (similar to the RJ11C), may damage the modem and the phone system. The only solution to this problem is to obtain a separate outside line for the modem.

(6) Connection of modem to telephone line through a Data Access Arrangement (DAA)

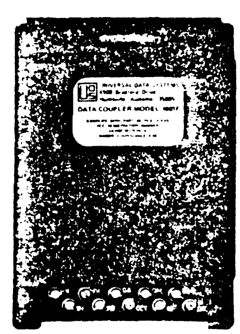
- Data Access Arrangement (DAA) - an external Registered Protective Circuitry (RPC). Its purpose is to protect the Telephone Company Central Office (CO) from harm in the form of of high voltage (115 vac shorting through power supply), high signal level (OdBm reaching the CO), and out of band frequencies. Sometimes called a data coupler.
- FCC Part 68 Registered
- Before direct connect modems were made, all devices that connected to the telephone line required a DAA.
- Very limited usage today because of direct connection of modems. In these types of devices the DAA is internal to the modem.
- There are three common types of DAA's: CDT (1000A) coupler, CBT (1001D) coupler, and CBS (1001F) coupler.



CDT1000A



CBT 1001D

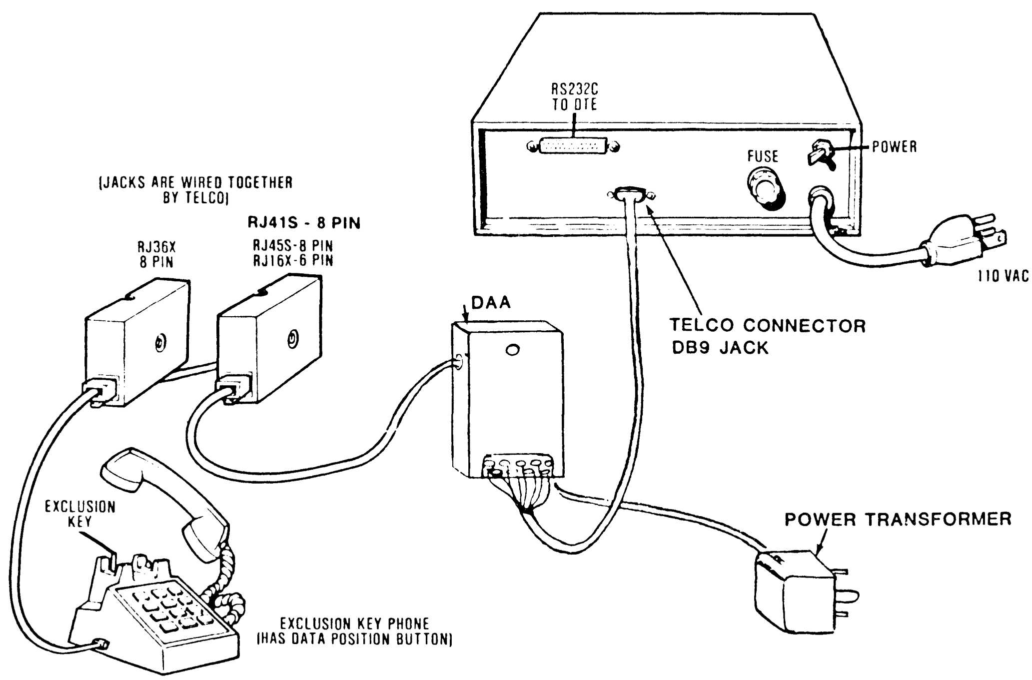


CBS 1001T

Common Types of Data Access Arrangements (DAA)

(B) Connection of DAA to modem and telephone line

- The DAA is normally connected to modem through a DB-9 9 pin connector.
- The DAA is connected to the telephone line through an RJ16X, RJ45S or RJ41S Jack.
- An Exclusion Key Telephone is used to manually place and answer calls. The Exclusion Key Telephone is connected through an RJ36 Jack.
- A wall mounted power transformer is used to power CBS(1001F) DAA's. CDT(1000A) DAA's are powered from the telephone line. CBT(1001D) DAA's are powered from the modem.



TYPICAL DATA ACCESS ARRANGEMENT CONFIGURATION

(C) DAA Interface Signals

- There are two interfaces on a DAA: the telephone line interface and the modem interface.

- Telephone line interface leads are the same as those used on the Registered Jacks: Tip (T), Ring (R), Program Resistor (PR), Program Resistor Common (PC), Mode Indicator (MI) and Mode Indicator Common (MIC).

- Modem Interface Leads

  - Data Tip (DT) and Data Ring (DR) - Analog signal leads that interface to the telephone line. DT and DR are the same as T and R of the telephone line except they are isolated by a transformer and other protective circuitry.

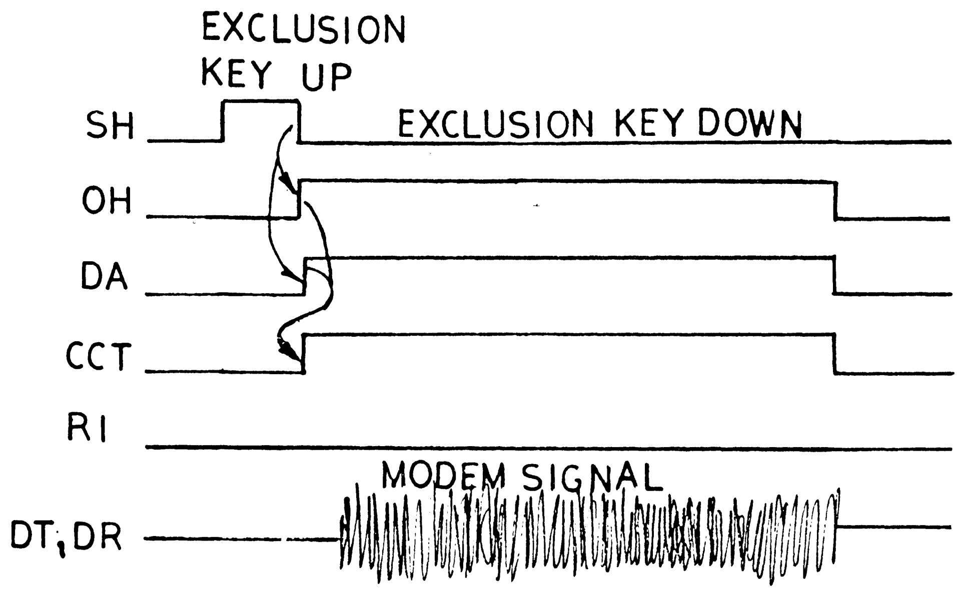
  - Switch Hook (SH) - indicates status of Exclusion Key. MI and MIC open indicated by a low state on this lead. MI and MIC shorted are indicated by a high state on this lead. This signal is to the modem from the DAA.

  - Off Hook (OH) - indicates that the modem wants to close the Off Hook relay (connect to the telephone line). This signal is to the DAA from the modem.

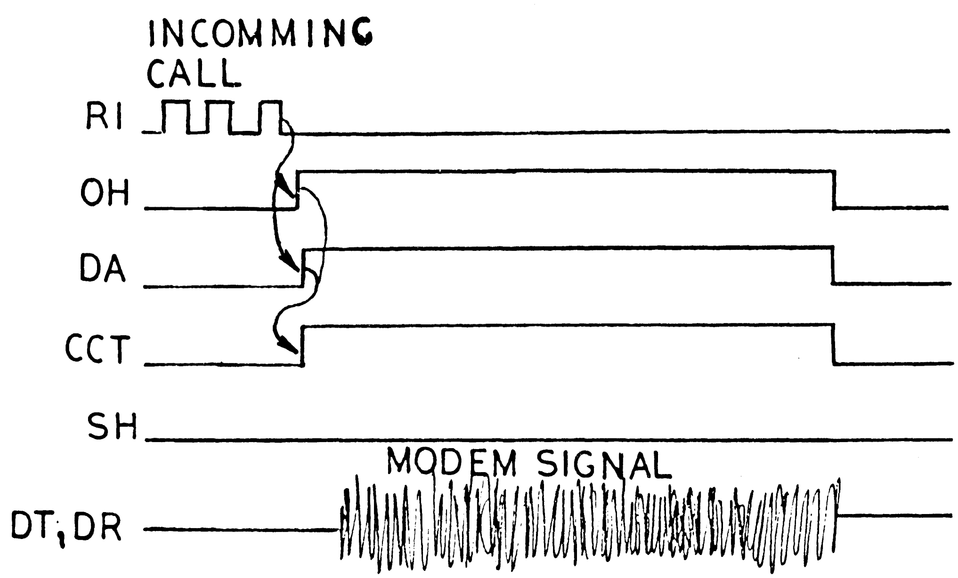
  - Data Access (DA) - indicates that the modem wants to close the coupler cut through (CCT) relay to allow data to be passed through the DAA. This signal is to the DAA from the modem.

  - Coupler Cut Through (CCT) - indicates that CCT relay is closed. Allows data to be passed through the DAA. DA and OH must be high before the CCT relay will close. If the modem output level on DT and DR is too high the "over load LED" will light, the CCT relay will open (prevents high level signal from being sent to the CO), and the CCT lead will go low. The DAA will stay in this state until the high signal level signal is removed. This signal is from the DAA to the modem.

- Ring Indication (RI) - indicates that a ringing signal is present on the tip and ring leads (receiving an incoming call). The modem normally responds to ring indication by raising OH and DA. This causes the DAA to answer the call. This signal is from the DAA to the modem.



Typical DAA Connect Sequence for Call Origination

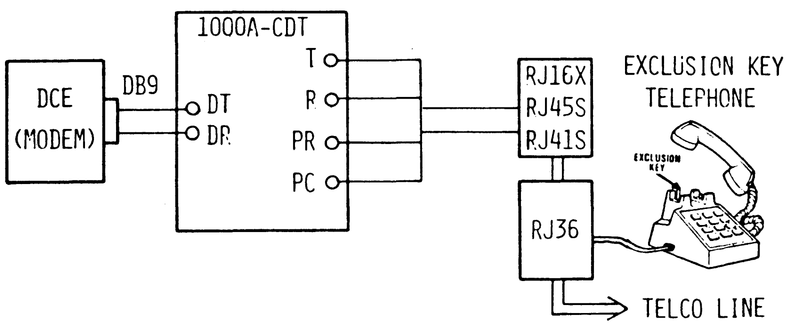


Typical DAA Connect Sequence for an Incoming Call

(D) Types of DAA's

. <u>CDT (1000A) DAA</u>

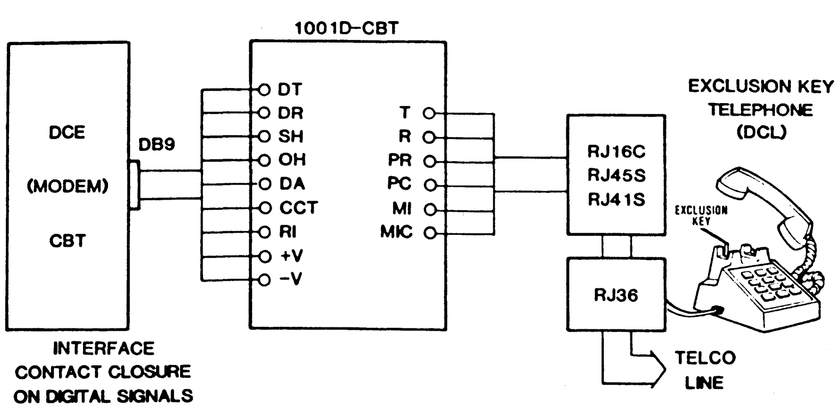
- All calls must be manually placed and answered.
- Requires Exclusion Key Telephone wired for "Telephone Set Controls the Line (TCL)."



CDT(1000A) DAA

. CBT(1001D) DAA

- Calls may be automatically answered by the modem/DAA.
- Calls may be manually answered with an Exclusion Key Telephone.
- Uses Exclusion Key Telephone wired for "Data Set Controls the Line."
- Interface signals between modem and DAA are contact closures.



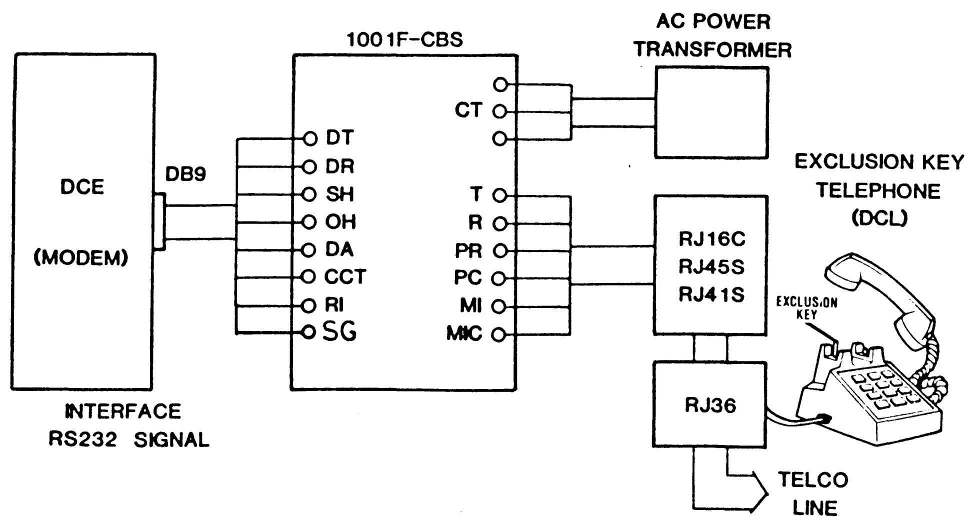
CBT(1001D) DAA

- CBS(1001F) DAA
  - Calls may be automatically answered by the modem/DAA.
  - Calls may be manually answered with an Exclusion Key Telephone.
  - Uses Exclusion Key Telephone wire for "Data Set Controls the Line."
  - Interface signals between modem and DAA

    "On"- +3V to +25V

    "Off"- -3V to -25V

    Undefined- +3V to -3V



B. Private (Dedicated, Leased) Line Interface

- Connection to a private line (3002 or DDS Network) is through a <u>Network Terminating Equipment (NTE)</u> device.

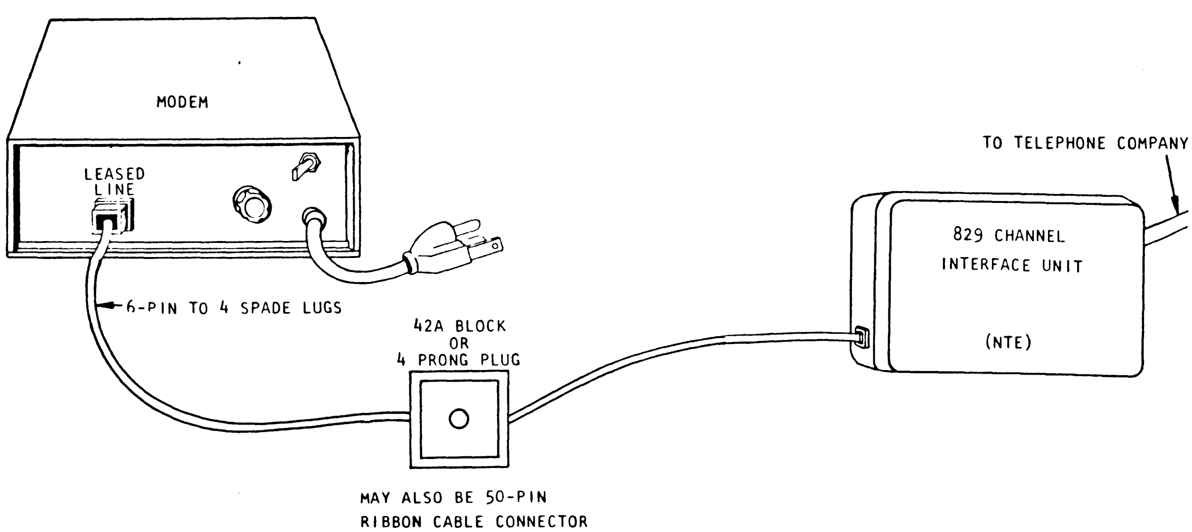
- The purpose of the NTE device is to protect the Telephone Company CO, make adjustments for the line, and provide connection interface for Data Circuit-Terminating Equipment (DCE - modem or DSU/CSU).

(1) Connection to a 3002 Private Line (C1, C2, C4, D1, D2)

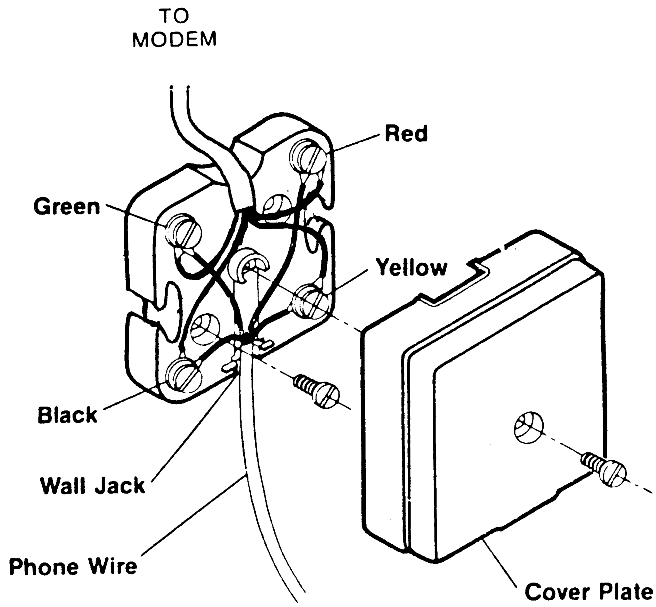
  - This interface is defined by proposed EIA Standard PN 1372. Defines requirements for modem interface and network.

  - Most private leased lines are 4-wires. A 2-wire leased line may be formed by using a 4-wire to 2-wire hybrid. This hybrid is contained in the 829 channel interface unit.

  - Connection to the 829 channel interface unit may be through a 42A block, 4 prong plug/receptical (types 283B plug, 404B receptical), or 50 pin miniature ribbon connector.



Private Line Connection through 829 Channel Interface Unit

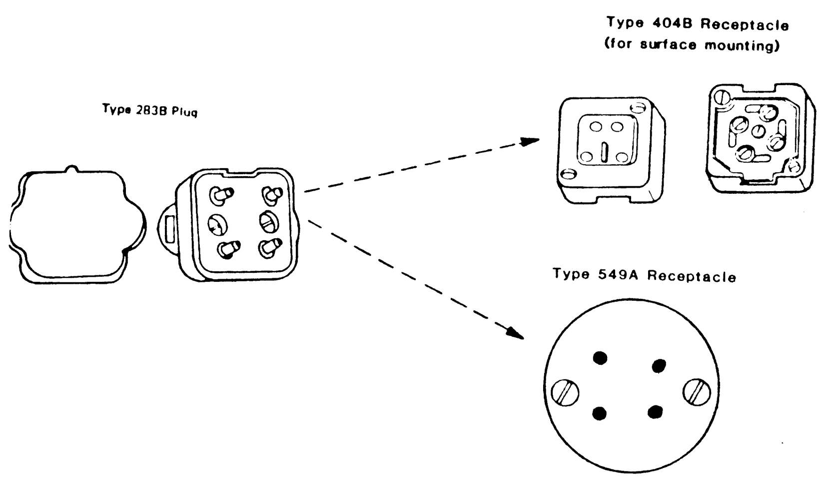


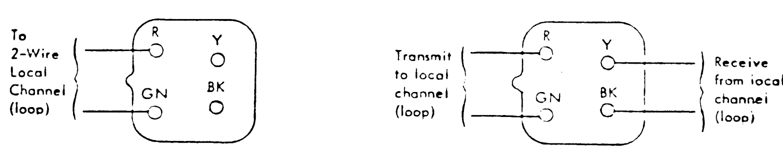

```
4-wire Termination
   Red      Transmit
  Green       Pair
 Yellow     Receive
  Black       Pair

Red/Green and Yellow/
 Black are not
  Polarity Sensitive

  2-wire Termination
     Red      Transmit
   Green        and
              Receive
                Pair
```

Private Line Connection to 42A Block

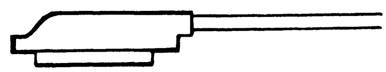




Two Wire Termination   Four Wire Termination

Private Line Connection to 4-Prong Plug/Receptical

50-PIN RIBBON
CABLE CONNECTOR

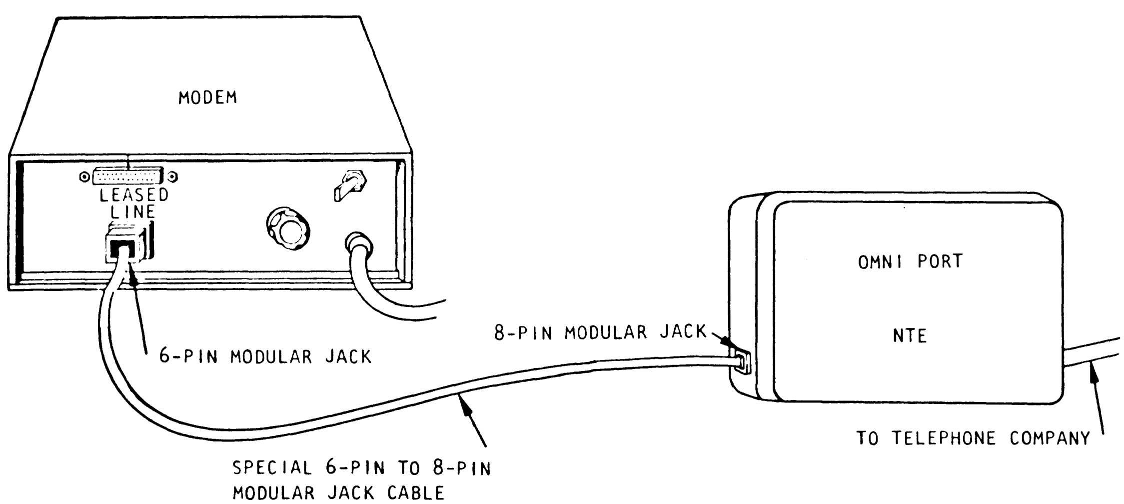


Pin 4 Pin 29	}	Transmit Pair
Pin 5 Pin 30	}	Receive Pair

Private Line Connection to 50 Pin Ribbon Cable Connector

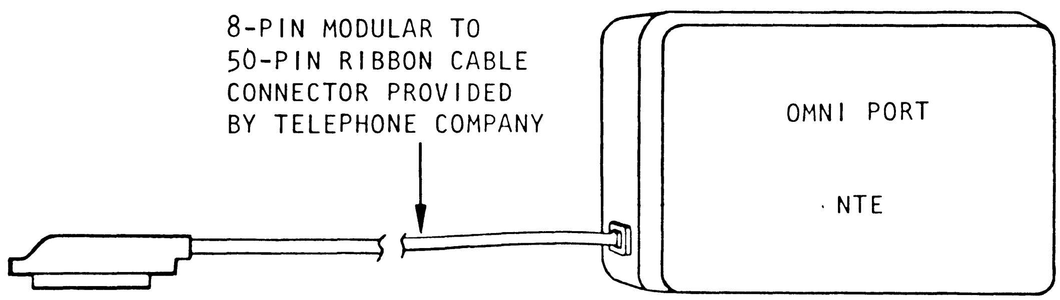
- A new type of NTE is the <u>Omni</u> <u>Port</u> (Bell Port 146A).

- Connection to the Omni Port is through an 8 pin modular Jack or a 50 pin ribbon cable connector (uses adaptor cable).



Pin No.	Signal Name
1	Receive Pair
2	4-wire
3	TEK 5 loop back indication
4	Not used
5	Not used
6	TEK 6 loop back indication common
7	Transmit or Transmit/Receive
8	Pair 4-wire or Pair 2-wire

Private Line Connection to Omni Port-8 Pin Modular Jack



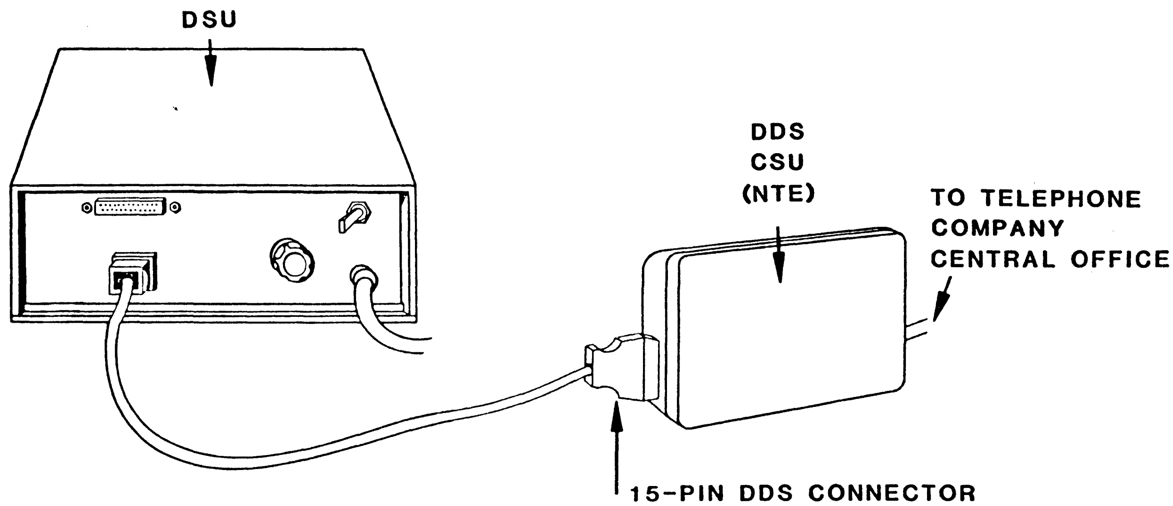
50 Pin Ribbon Cable Connector to Modem

Pin NO.	Signal Name
4 29	Transmit or Transmit/Receive Pair - 4 Wire or Pair - 2 Wire
5 30	Receive Pair - 4 Wire
28	TEK 5 - Loop back indication
3	TEK 6 - Loop back indication common

Private Line Connection to Omni Port through 8 Pin to 50 Pin Adaptor Cable

(2) Connection to Digital Data System (DDS) private line network.

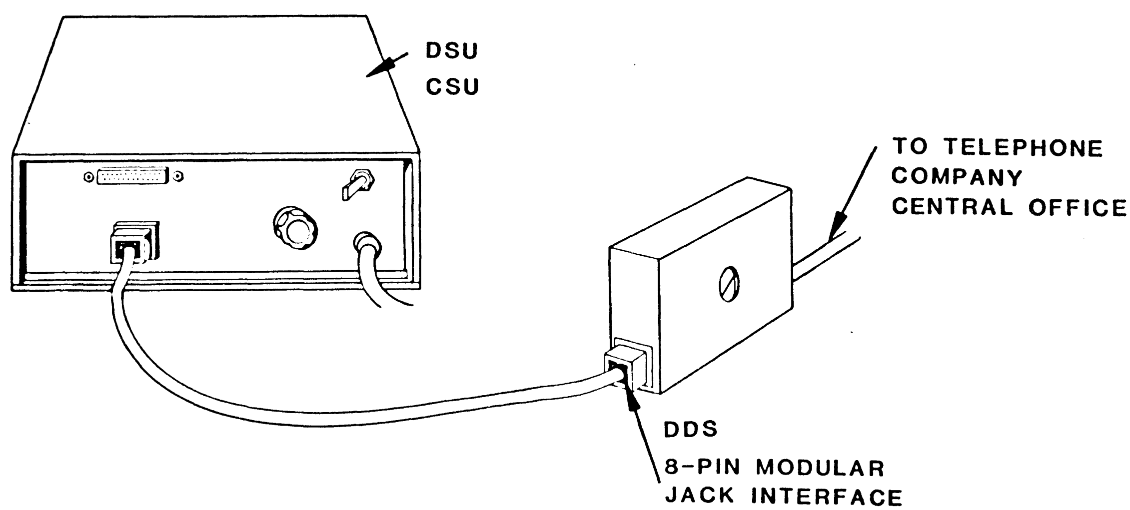
- A different DDS NTE device is provided for each speed (56K bps, 9.6K bps, 4.8K bps, 2.4K bps).



DDS CONNECTOR

PIN		SIGNAL
1	—	SIGNAL GROUND
2	—	STATUS INDICATOR (S1)
3	—	RECEIVE SIGNAL FROM DDS NETWORK
4	—	RECEIVE SIGNAL RETURN
5	—	TRANSMIT SIGNAL TO DDS NETWORK
6	—	TRANSMIT SIGNAL RETURN
7-15	—	NOT USED

DDS Connection to NTE



8-PIN MODULAR JACK INTERFACE

PIN	SIGNAL
1, 2	TRANSMIT PAIR
4-6	NOT USED
7, 8	RECEIVE PAIR

DDS Connection to 8-Pin Modular Jack Interface

11. Special Devices

(A) 801 Automatic Calling Units (ACU)

(1) Permits automatic dialing of telephone numbers for modems on the Public Switched Telephone Network (PSTN)

(2) Four types of 801 ACU's
- 801A - ACU with pulse (rotary) dialer that uses RS366 parallel interface to connect to Data Terminal equipment (DTE).

- 801C - ACU with Dual Tone Multi-Frequency (DTMF-Touchtone) that uses RS366 parallel interface to connect to Data Terminal Equipment (DTE).

- 801AS - ACU with pulse (rotary) dialer that uses RS232C asynchronous serial interface to connect to DTE.

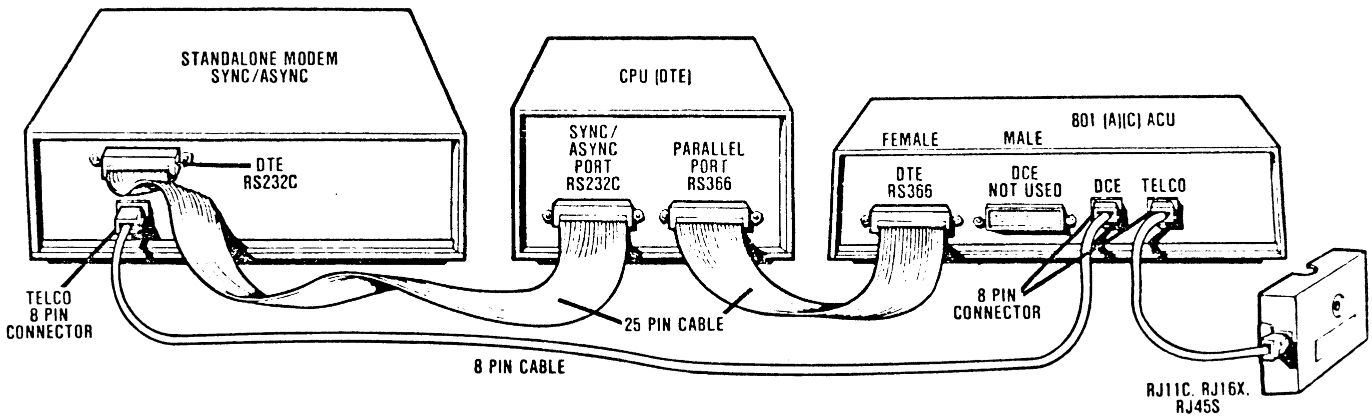
- 801CS - ACU with Dual Tone Multi-Frequency (DTMF-Touchtone) that uses RS232C asynchronous serial interface to connect to the DTE.

- All four types are available in one unit. Types are selected by strap options.

- Serial 801ACU are only available from UDS.

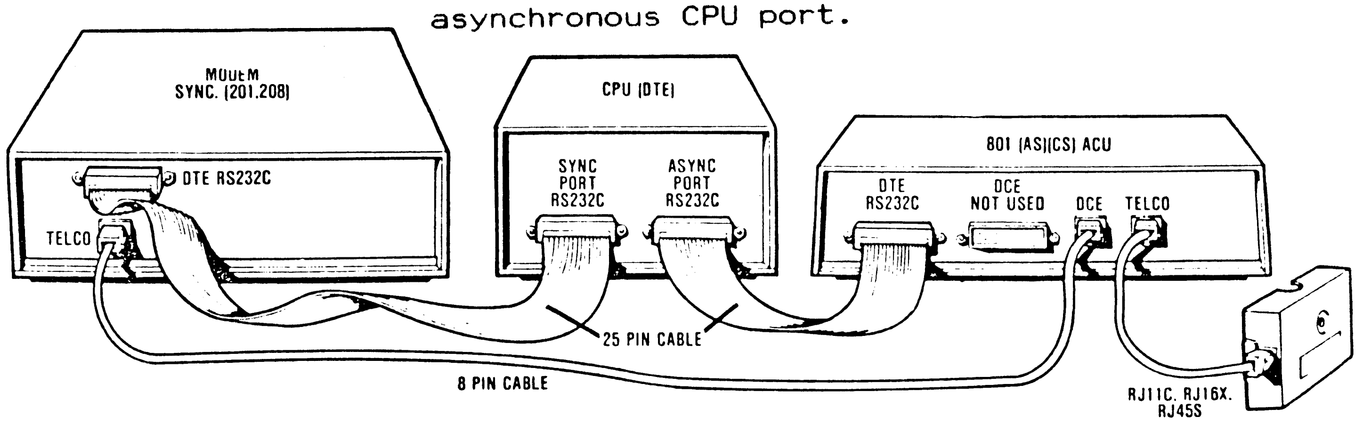
(3) Three 801 ACU Configurations

- Parallel RS366 Configuration - the 801 ACU is connected to the CPU through a parallel RS366 port. Synchronous modem is connected to a synchronous CPU port or an asynchronous modem is connected to an synchronous CPU port.



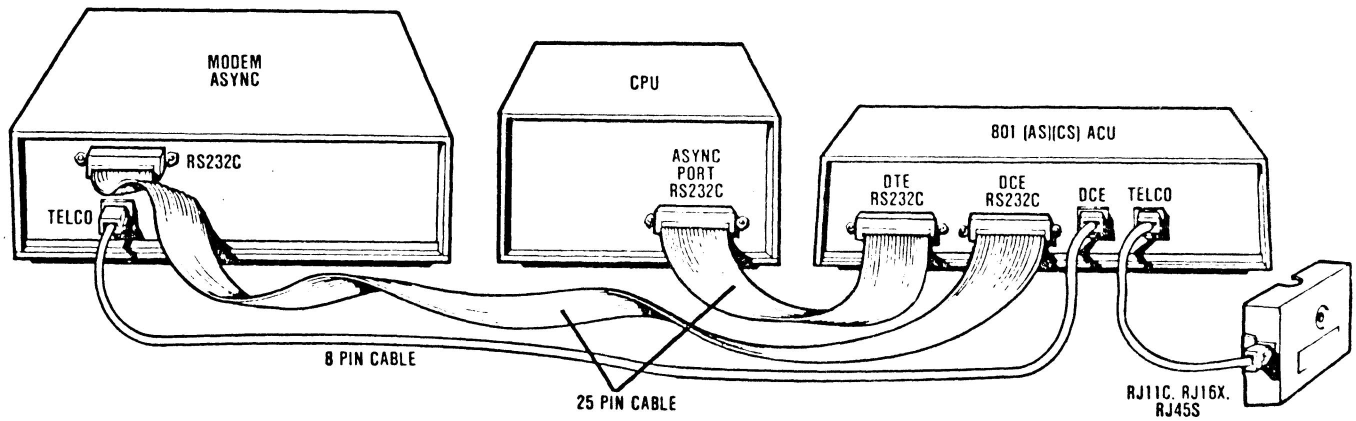
Parallel RS366 Configuration

- Dedicated RS232 Configuration - the 801 ACU is connected to the CPU through a serial asynchronous RS232 port. Synchronous modem is connected to a synchronous CPU port or an asynchronous modem is connected to an asynchronous CPU port.



Dedicated RS232 Configuration

- Shared RS232 Configuration - the 801 ACU and asynchronous modem are shared by one serial asynchronous RS232 CPU port.



Shared RS232 Configuration

(4) Special terms associated with 801 ACU's.

- Pulse or Rotary Dialing
  The pulse occurs at a 10 $\pm$ 1 pulse-per-second rate. The pulse is 60% break and 40% make with 700 ms between digits.

- Dual Tone Multi Frequency (DTMF) or Touch Tone
  The ON time of the tone is 60 ms with a 70 ms inter-digit time. The output tone level is 4 dB above the modem output level.

- Dial Tone Detection
  The ACU recognizes a dial tone if the signal is there continously for approximately 1 second. The frequency must be between 200 and 1000 Hz. The level must be -30 dB or greater.

- Tandem Dial Control (Second Dial Tone Detection)
  The dial tone detection circuitry is reset when the received digit (from the DTE) is 1010_2 (10_{10}). The ACU will look for a dial or BUSY signal before proceeding with the call.

- Answer Back tone (ABT) Detection
  The ACU will recognize a signal as an answer tone if it is 2125 Hz $\pm$ 100 Hz, the level is 0 to -42 dB, and it occurs for at least 1.5 seconds.

- Busy Signal Detection
  The ACU detects a BUSY signal (if the called number is BUSY) and sends the BUSY character to the DTE or turns on the ACR line.

- Abort Timer (ACR)
  The ACU has a timer which starts when CRQ is turned On and gets reset each time a digit is dialed. The timer is selectable to be 12.8, 25.6, 51.2, or 102.4 seconds. The call is aborted if ABT is not detect selected amount of time.

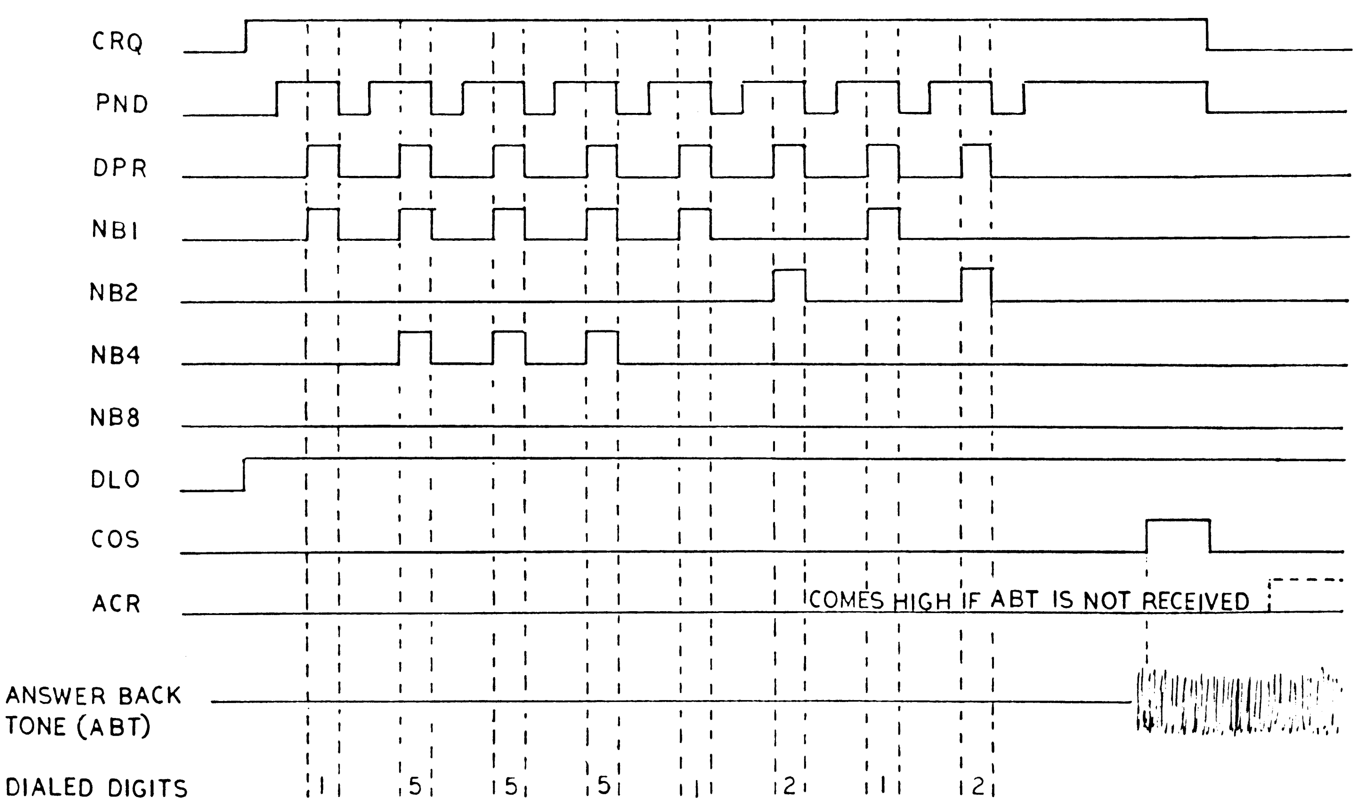
- End of Number
  The ACU recognizes the code 1100_2 (12_{10}) as the EON code. If the ACU receives the EON code, the modem is connected to the telephone line without receiveing ABT, the COS line will turn On. If EON is not used, the ACU waits to detect the ABT before connecting the modem to the telephone line.

(5) Parallel RS366 Data Format for DTMF (Touch Tone Auto Dialing).

Dialed Digit	NB8	NB4	NB2	NB1	Frequencies (Hz)
0	0	0	0	0	941 and 1336
1	0	0	0	1	697 and 1209
2	0	0	1	0	697 and 1336
3	0	0	1	1	697 and 1477
4	0	1	0	0	770 and 1209
5	0	1	0	1	770 and 1336
6	0	1	1	0	770 and 1477
7	0	1	1	1	852 and 1209
8	1	0	0	0	852 and 1336
9	1	0	0	1	852 and 1477
Tandem Digit (Option)	1	0	1	0	
Pause Light	1	0	1	1	
Eon	1	1	0	0	Tandem Digit
(Option)	1	1	0	1	
Unused	1	1	1	0	

(6) Parallel RS366 Control and Data Leads

- Power Indication (PWR).....On when power is supplied to unit.
- Call Request (CRQ).....On when ACU has control of interface leads.
- Data Line Occupied (DLO).....On if ACU attempts call when DCE is off hook. On when CRQ is On.
- Present Next Digit (PND).....On when ACU has detected dial tone, remains on until call is completed.
- Digit Present (DPR).....On while digits are being dialed.
- Call Origination Status (COS).....On when call has been completed satisfactorily (if CRQ is On).
- Digit Signal Circuits (NB1, NB2, NB4,NB8)... Parallel Data input to ACU. Low indicates Mark. High indicates Space.
- Abandon Call and Retry (ACR).....On when call has not been completed because of no anwer back tone, abort timer has run out, or busy signal was received.



Timing Diagram for Parallel RS366 Auto Dialing

(7) Serial RS232C Asynchronous Auto Dialing Format

• Control Characters – From DTE

	Bit Pattern 7	6	5	4	3	2	1	Function
STX	0	0	0	0	0	1	0	Start Format
ETX	0	0	0	0	0	1	1	End Format
EOT	0	0	0	0	1	0	0	Abort Call

• Dial Digit Characters – From DTE

Digit	Bit Pattern 7	6	5	4	3	2	1	ASCII
0	0	1	1	0	0	0	0	0
1	0	1	1	0	0	0	1	1
2	0	1	1	0	0	1	0	2
3	0	1	1	0	0	1	1	3
4	0	1	1	0	1	0	0	4
5	0	1	1	0	1	0	1	5
6	0	1	1	0	1	1	0	6
7	0	1	1	0	1	1	1	7
8	0	1	1	1	0	0	0	8
9	0	1	1	1	0	0	1	9
Tandem (Option)	0	1	1	1	0	1	0	:
Pause (Option)	0	1	1	1	0	1	1	;
EON (Option)	0	1	1	1	1	0	0	<
Tandem (Option)	0	1	1	1	1	0	1	=
Last Digit	0	1	1	1	1	1	1	?

. Data Format - From DTE

Block No.	Function
1	STX
2 through X	Dial Digits (desired length) (up to 25 digits)
X + 1	EON (follows last ACU digit) (option)
X + 2	Last Digit (follows last digit character) -?
X + 3	ETX (follows last digit character)

Example of Serial Asynchronous Character String for Placing Call:

STX 1 8 0 0 5 5 5 1 2 1 2 ? ETX

. Redial Format - from DTE
The DTE may direct the ACU to re-dial the last telephone number dialed by sending STX followed by ETX.

Example of Serical Asynchronus Character String for Redialing Last Number Called:

STX ETX

. Abort Procedure - From DTE (Before DCE enters Data Mode)
The DTE may abort the call at any time by turning the RTS signal Off (Low Level) or transmitting an EOT character (preceded by STX) when strapped for STX control.

Example of Serial Asynchronous Character String for Aborting Call:

STX EOT

. Response Characters - from ACU to DTE indicates call progress status

	ASCII	Bit Pattern 7	6	5	4	3	2	1	Function
DLO	D	1	0	0	0	1	0	0	Data Line Occupied
COS	C	1	0	0	0	0	1	1	Call Originate Status
ACR	A	1	0	0	0	0	0	1	Abandon Call and Retry
Busy	B	1	0	0	0	0	1	0	Busy (Remote)
Error	E	1	0	0	0	1	0	1	Character Error

B. Auto Dialing Modems (Smart Modems)

(1) In the future most modems will have auto dialers built into the modem. At this point there is very little standardization of the auto dial command structure.

(2) Sample auto dialing modem command structure (used in UDS 212A/D)

Async Character	Command Description
H	Print Command Directory
D	Dial from Keyboard (7 digits)
R	Repeat Last Digits
(L1-L5)	Load, Contents of Digit Set (up to 30 digits)
(1-5)	Dial Store Digits
CL	Clear, Contents of Stored Digits (All)
C(1-5)	Clear, Specific Stored Digit
P	Print, Contents of Stored Digits
B	Busy Out Telco Line
N	Release Busy Condition
Q	Quit, Any Operation of ACU
O	Options

(3) Sample of special dial characters used in modem auto dialers (used in UDS 212A/D)

Async Character	Dial Character Description
W	Wait for Second Dial Tone
D	Delay (3 Second Pause)
E	End of Number (Turns Telco Line to Telset)
A#	Append Number (Retry Number)
(SP)	Space

(4) Example of asynchronous character strings used with auto dialing modems.

- **Async Character String to Load Number into auto dialer memory:**

  L1 81 W 15551212 A3

  L1 - loads in to memory location 1
  81 - connect to outside watts line
  W - waits for second dial tone
  15551212 - telephone number to be dialed
  A3 - if busy or no answer, dial number contained in memory location 3.

- To Dial number located in memory location 1.

  1 (typed by user)

  8115551212 call complete (from auto dialer)

C. Modem Sharing Devices (MSD) - UDS model 701

- Permits four external intelligent DTE devices to be connected to the telephone line through one modem.

- The modem link is normally full duplex.

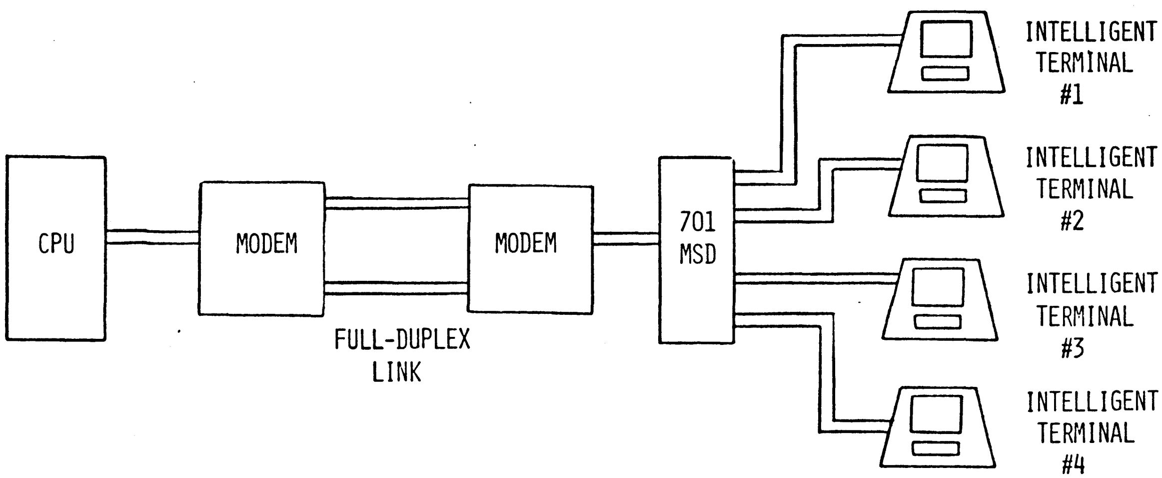
- DTE ports may be synchronous or asychronous. All ports must be configured the same (async or sync). In the synchronous mode a single character buffer may be enabled to permit each terminal to use its own transmit clock. Data is clocked into the buffer with the terminals clock. Data is clocked out of the buffer into the modem with the modems clocks.

- When configured for async terminals, the modem must be async. If configured for sync terminals, the modem must be sync.

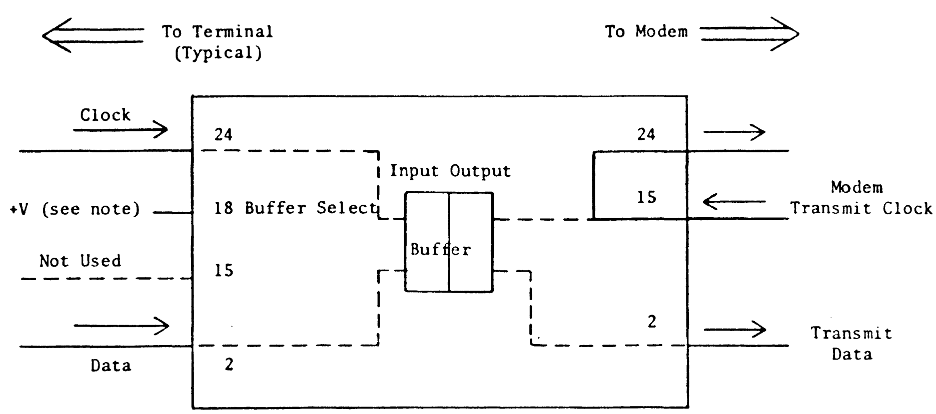
- May be operated with data rates up to 9600 bps.

- Terminals must respond one at a time to a unique poll code by raising Request to Send (RTS). Only one terminal at a time may raise RTS.

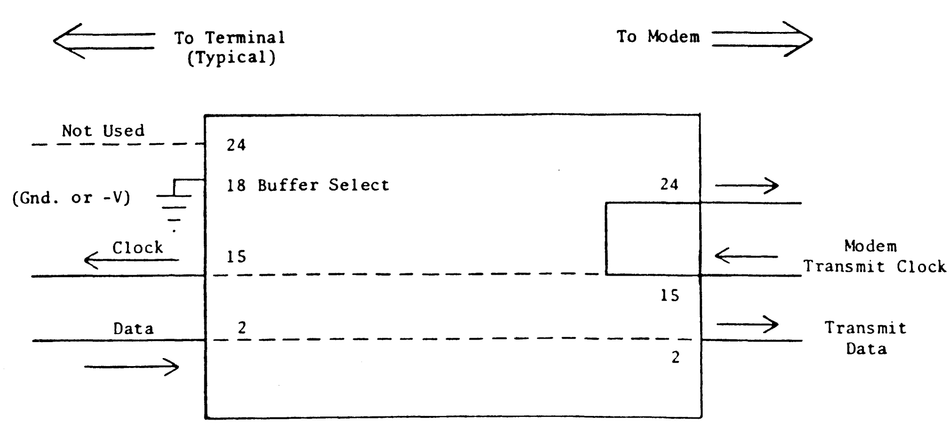
- Essentially the MSD is an RS232 switch, where RTS controls which port is selected for connection to the modem.



Typical Modem Sharing Device (MSD) Configuration

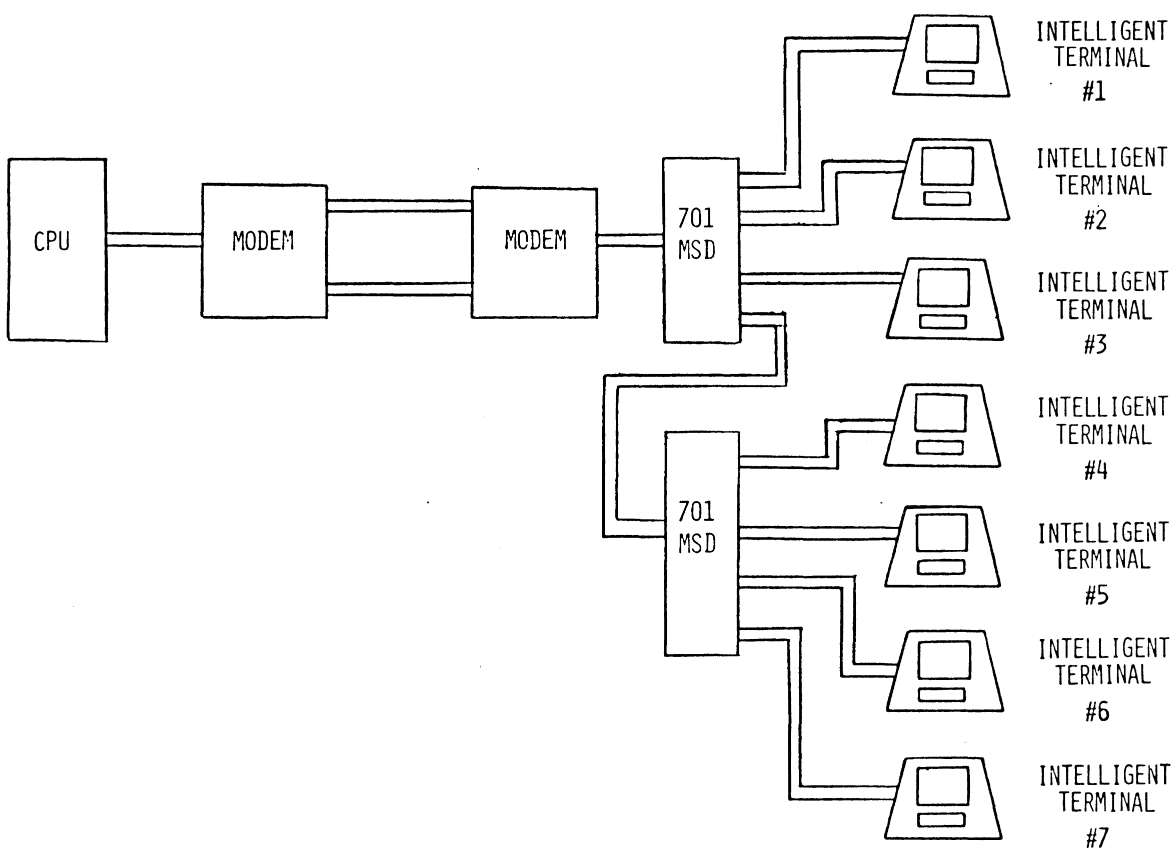


MSD with One Character Buffer Enabled



MSD with One Character Buffer Disabled

- Modem sharing devices may be cascaded. Thus, additional MSD's may be connected to the terminal ports to increase the number of terminals that may be connected. There is no limit to the number of MSD's that may be cascaded, but the practical limit for most systems is 16 ports.



Cascading of Modem Sharing Devices

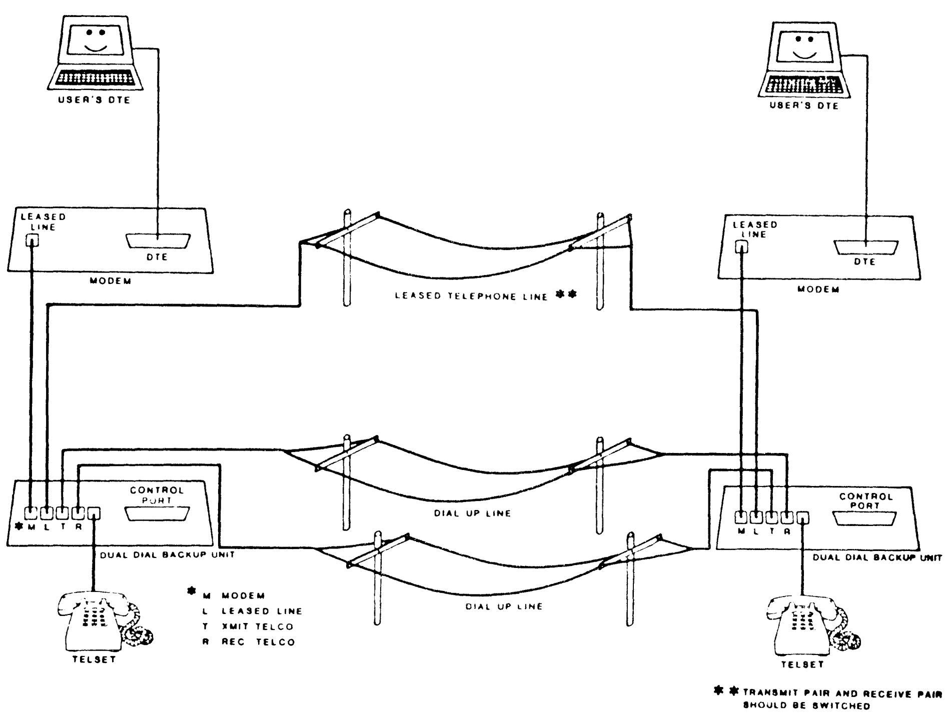
D. Dual Dial Back Up Units (DDBU) - UDS Model 720

- Allows a modem that is designed to operate over a private leased line to operate over two dial-up telephone lines.

- In normal mode, modem is connected to private leased line. When back up mode is selected, modem is connected over two dial-up telephone lines.

- May be used to back up private line, in case of private line failure.

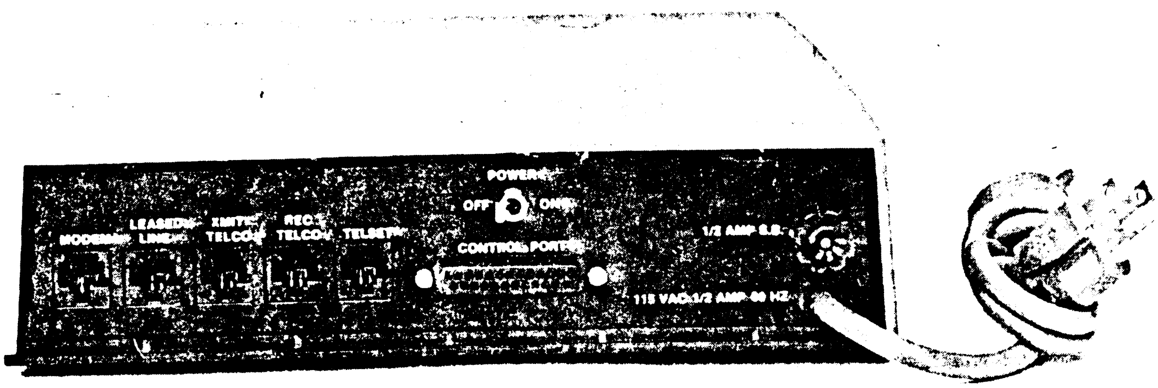
- May be used permanently in backed up mode over dial up lines to permit 4-wire full duplex operation.



Typical DDBU Configuration

- Rear panel contains modular Jacks for connecting to:

  - private line modem
  - 4-wire leased telephone line
  - transmit dial-up line
  - receive dial-up line
  - telephone set



Rear Panel for DDBU

- Four ways to enter back up mode:

  - Through special control lead on RS232 control port. High on control lead causes DDBU to automatically go in to back up mode (automatically places two telephone calls).

  - Through async control port DTE may give DDBU commands to go into back up mode. Commands are similar to those used with auto dial modem.

  - Through automatic back up mode switch on on the front panel.

  - Through manually placed calls via the telephone set plugged into the rear of the DDBU.

E. Async to Sync Converters - UDS Model 210A/SP

- The purpose of an async to sync converter is to permit interfacing of asynchronous terminal equipment (computer) to synchronous modems.

- Synchronous modems operate at higher speeds than asynchronous modems. This is due to the modulation techniques required to "fit" the higher data rates onto the telephone line.

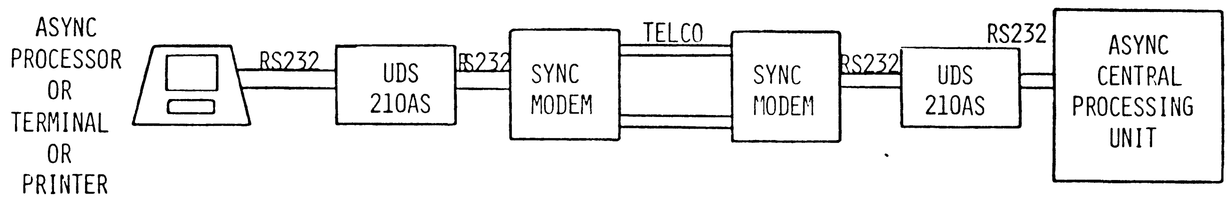
- Asynchronous modems are typically limited to 1200 bps. Many users find that 1200 bps is too slow.

- The user finds that he must either buy all new terminal equipment of the synchronous type or operate at a slower data rate.

- The async to sync converter is divided into two sections; the modem or synchronous section and the DTE or asynchronous section. The two sections are connected together with a one character buffer which make up the heart of the converter.

  - The synchronous section of the converter interfaces with the modem. The modem's clocking is used to synchronize the data out of the converter. Synchronous modems require synchronization of clock and data.

  - The asynchronous section of the converter takes in incoming data from in the DTE and either delays the data rate or speeds up the data rate. This is accomplished by adding or deleting stop bits. DTE equipment uses internal clock sources to generate the transmited data output. The DTE's internal clocks are not accurate enough for synchronous modems. The DTE's data rate will often vary plus or minus 1% of the speed setting. The converter has the ability to compensate for +1% high and -2.5% low data rates. Additionally, asynchronous transmission has an indefinite time interval between characters. Thus, there is a very high probability that the terminal equipment will transmit data out of phase with synchronous modem's clock. In this case, the converter will synchronize data to the modem's clock.

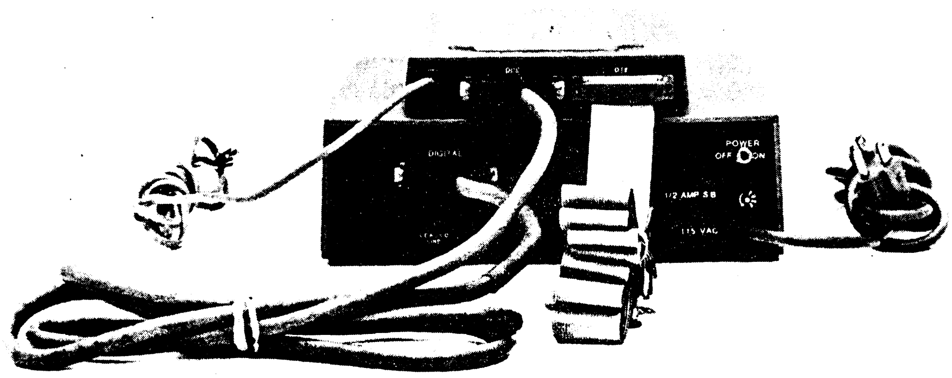


System Configuration using 210A/S-P Async to Sync Converter

- Typical system will require pin to pin cable (1 to 1, 2 to 2, etc.) from the computer to the async to sync converter and from the async to sync converter to the modem.

- If the terminal was previously connected directly to the computer, a cross-over cable may have been used between the computer and the terminal. This cross-over cable cannot be used with the async to sync converter because the transmit (pin 2) and receive (pin 3) are connected opposite to those on the async to sync converter.

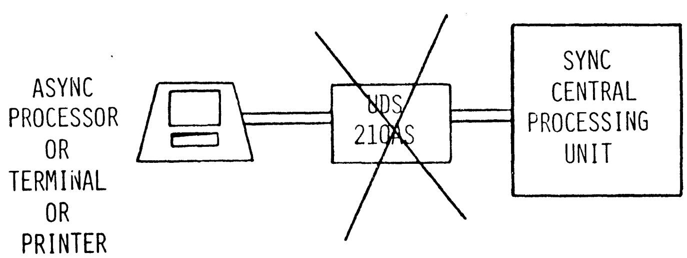
- If the computer port and cable were previously configured for connection to a modem, a pin to pin cable may have been used. In this case, the cable can be used for connection to the async to sync converter.



Rear Panel Asynchronous to Synchronous Converter Shown With Modem

Notes of Caution

1. The async/sync converter must be used with async/sync converter of the same manufacturer because not all manufacturers use the same method of conversion.
2. Async/sync converters are not protocol converters. Protocol converters are used to connect asynchronous DTE equipment to synchronous DTE equipment.



Async to Sync Converter is not a Protocol Converter

3. The async to sync converter does not have the intelligence to control the RS-232 control leads. The converter simply passes all control leads from the DTE through to the modem. Therefore, in configuring a system control lead compatibility must be considered.
4. The async to sync converter should only be used in systems with a constant carrier. Therefore, async to sync converters should not be used in half duplex dial-up applications. This is because synchronous modems inherently error at the leading and trailing edges of the carrier. Synchronous protocols are designed to correct for these leading and trailing errors, but async protocols typically do not have a means of correcting for these errors. This results in "garbage" characters leading and following data.

F. Error Correcting Units - UDS Model EC100

- The purpose of the Error Correcting Unit is to permit interfacing of asynchronous terminal equipment (computer) to synchronous (full or half duplex) modems and provide error correction of transmitted data.

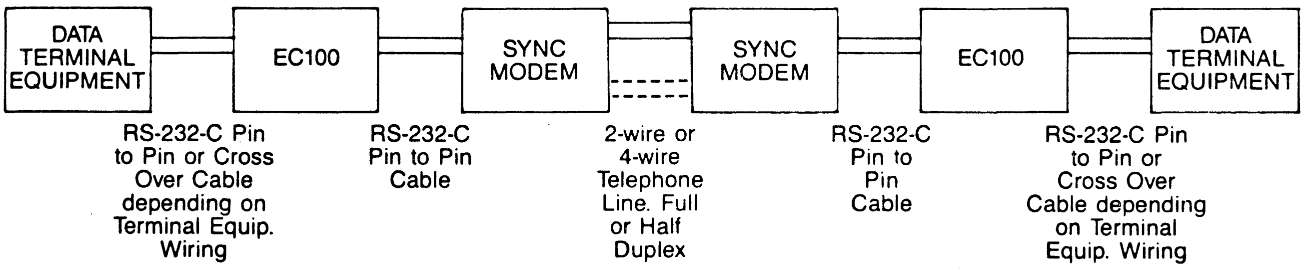
- Error Correcting Units may only be used in point to point application.

- Three main features:

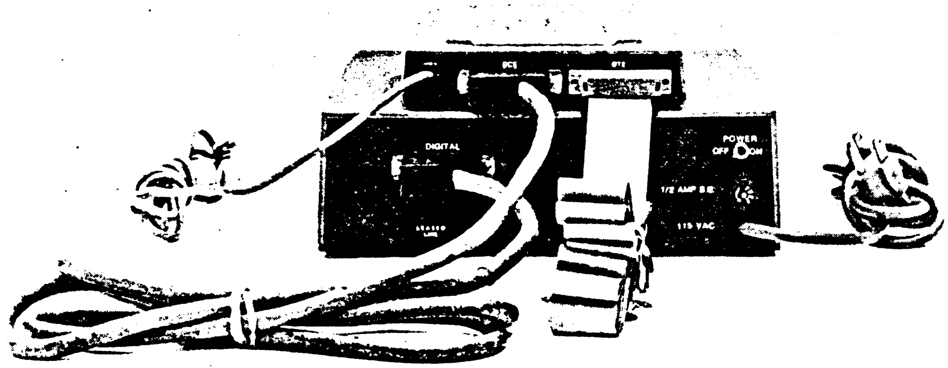
1. Async to Sync Conversion - The Error Correcting Unit converts asynchronous data from the TERMINAL (CPU) into a form of SDLC (SYNCHRONOUS DATA LINK CONTROL). The receiving Error Correcting Unit converts the SDLC back to asynchronous data for the receiving TERMINAL (CPU). Note: The EC100 cannot be used for protocol conversion.

2. Full to Half Duplex Conversion - In the half duplex mode of operation, the Error Correcting Unit recognizes incoming data from the terminal and performs all RS-232 control lead action necessary to function with a half duplex modem. This feature allows "DUMB" TERMINALS (CPU's) without control leads to operate at higher speeds (i.e.; 4800 or 9600 bps on a 2-wire line). The value of this feature cannot be over stressed. Customers may now use less expensive terminal equipment and avoid complex synchronous protocols, but still maintain high data rates. Additionally, the Error Corrector can be optional for full duplex operation. This allows the Error Correcting Unit to be used with full duplex synchronous modems or half duplex synchronous modems operating on 4-wire private lines.

3. Error Detection and Correction - As an additional bonus, the Error Correcting Unit provides data protection. This is accomplished by an AUTOMATIC RETRANSMIT SCHEME. The error detection and retransmission is totally TRANSPARENT to the terminal equipment. In other words, the terminal equipment never knows when the Error Correcting Unit is in a mode of retransmission, except for a slight delay in data output.



System Configuration Using EC100's Error Correcting Units



Rear Panel of EC100 Error Corrector Shown with Modem

- Typically the system requires a pin to pin (1 to 1, 2 to 2, etc.) from the computer to the Error Correcting Unit and from the Error Correcting Unit to the modem.

- If the terminal was previously connected directly to the computer, a cross over cable may have been used between the computer and the terminal. This cable cannot be used with the EC100 because the transmit data (pin 2) and receive data (pin 3) are connected opposite those on the EC100.

- If the computer port and cable were previously configured for connection to a modem, a pin to pin cable may have been used. In this case the cable can be used for connection.

- Flow Control is the handshaking method between the Error Correcting Unit and the terminal CPU to prevent data from being lost.

- Two types of Flow Control:

1. Internal Flow Control - Internal flow control is the method used by the Error Correcting Unit to stop the terminal equipment from outputting data. To illustrate the use of internal flow control, let's assume that the transmission line had degraded (high error rate) to a point where the Error Correcting Unit has difficulty in communicating with the remote Error Correcting Unit. As the internal buffer (4K bytes) fills with data from the local terminal, the Error Correcting Unit needs to tell the local terminal to stop outputting data or data will be lost. The Error Correcting Unit will inform the terminal of this condition by either an X-OFF character (in-band signaling) or by lowering an RS-232 Control Lead (strap selectable). It is important to note that different terminal equipment use different forms of flow control. The user manual for the terminal equipment should specify which form of flow control is used. When the transmission line has improved and the Error Correcting Unit's buffer has cleared out, the Error Correcting Unit will signal the terminal equipment to start transmitting again.

2. External Flow Control - External flow control is similar to internal flow control, except that with external flow control, the terminal equipment is telling the Error Correcting Unit that it cannot accept any more data and to stop outputting data. An example of this would be the operation of a printer. Let's say that a file was being sent to a printer and the printer ran out of paper. In this case, the printer would want the Error Correcting Unit to stop outputting data until more paper was loaded into the printer. The printer can use either an X-Off (in-band

signaling) or RS-232 Control Lead pin 20 (out-of-band-signaling) to tell the local Error Correcting Unit to stop outputting data. When paper is loaded back into the printer, the printer would inform the Error Correcting Unit to start outputting data.

- Flow Control Considerations:

1. Normally, flow control needs to be considered only at the CPU side of the circuit. When using "DUMB" terminals to access data from computer, a human manually keys in information from the keyboard and the computer is sending pages of information back to the display. A human would have to be an extremely fast typist to fill up a 4K buffer.

2. It is probable that a computer could send data at a faster rate than the Error Correcting Unit could transmit. An exception to this is the use of the printer. Printers can accept higher data rates than they can actually print and they can also run out of paper. If the system is configured for computer to computer operation, then flow control must be considered for each side of the link.

3. Two computers communicating with each other have a high probability of over flowing the Error Correcting Unit's buffer.

- Typical Error Correcting Unit Application:

THE PROBLEM: The customer's computer site is remotely located. His software people are doing development work on the computer. The computer and terminals are both asynchronous devices without RS-232 control leads. The customer wanted to have a dedicated 4-wire line installed. He found that the lead time was very long and the tariff was very high. Rather than move his people to the computer site, he wants to operate over a dial-up line, because they are so much less expensive. He tried using 212A's, but found that they were too slow. What can he do?

THE SOLUTION: This would be a perfect application for the Error Correcting Unit and either the 208A/B or 9600A/B. The reason is that these modems will give him the speed that he is looking for to accomplish his work. Also, he may still use the same equipment if he decides to install a private line at a later date. Since his application is software development, he will require error free transmission. A bad character entered into the computer will cost him money, because his people will have to DE-BUG the error.

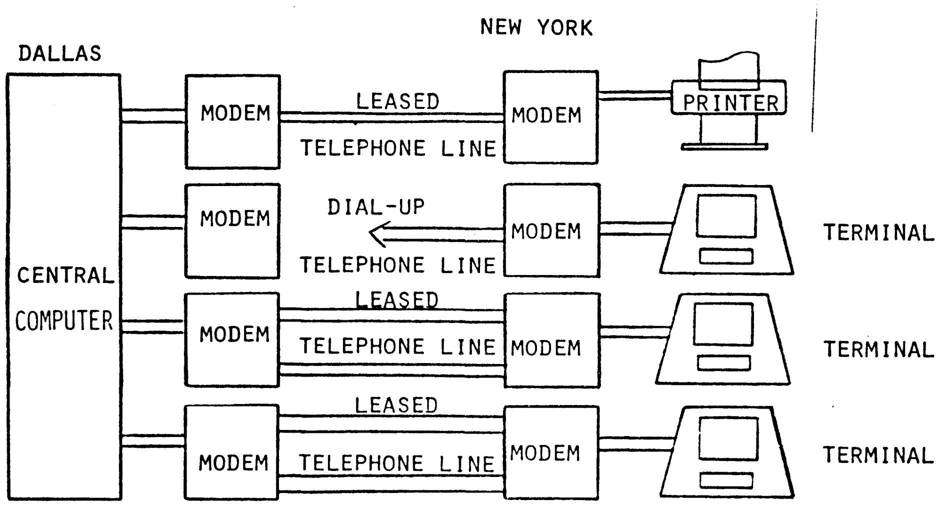
The next consideration is flow control of the computer. If the programmers request only one display at a time (normally one display consists of 2K bytes of data), then flow control is not required. This is because the Error Correcting Unit has a 4K byte buffer. If the programmers are calling up multiple displays or data greater than 4K bytes, then flow control should be used.

If the computer uses X-ON/X-OFF flow control, then strap the Error Correcting Unit for this operation. If the computer uses control lead flow control, the proper RS-232 pin must be used. Not all computers use the same pins for flow control. The Error Correcting Unit uses either Pin 5 or Pin 11 for internal flow control and Pin 20 for external flow control. The cable between the terminal/computer and the Error Correcting Unit must be wired appropriately.

G. Multiplexers (MUX)

(1) There are two approaches to linking multiple terminals into a CPU located in another city: separate lines and single multiplexed line.

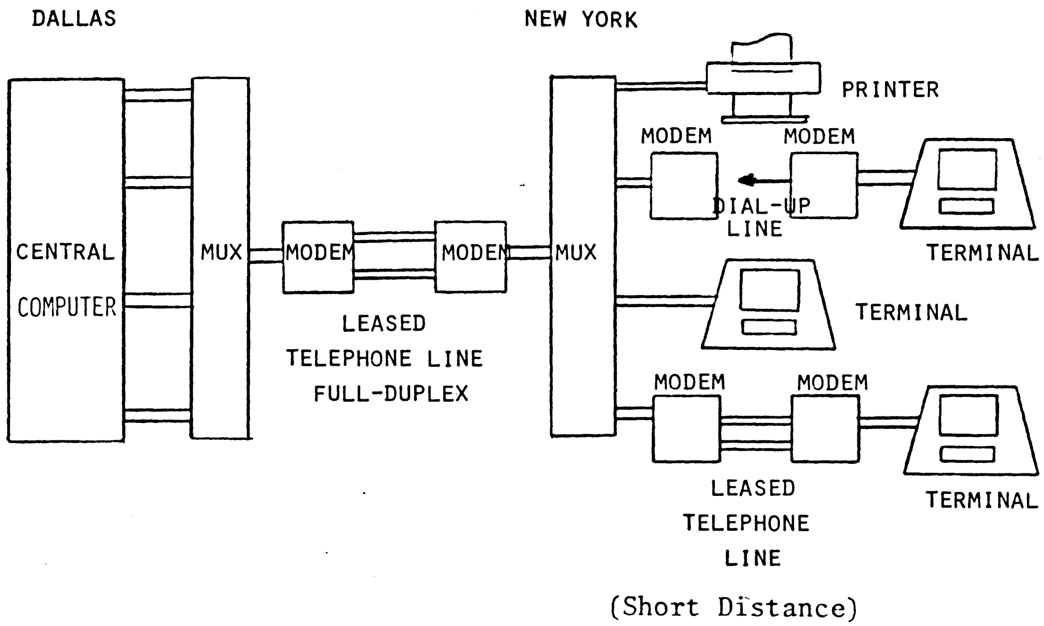
- Separate telephone lines for each DTE device. The telephone lines may be PSTN or private leased lines.



Typical Approach Used to Link Multiple Terminals into a CPU Located in another City using Separate Lines

- Example: CPU is located in Dallas, Texas. Remote terminals are located in New York. Three leased lines and one dial up line are used to connect the remote terminals. The leased lines are being rented 24 hours a day from the Telephone Company. Very seldom are all three terminals and the printer being operated at the same time. The printer is used mostly at night to print out the reports that were created during the day. The terminal using the dial up line places calls over the dial up network three or four times a day for about two hours. A lot of money is being wasted on three leased lines and long distance Calls.

- Single Multiplexed Line may be used to connect all four DTE's.



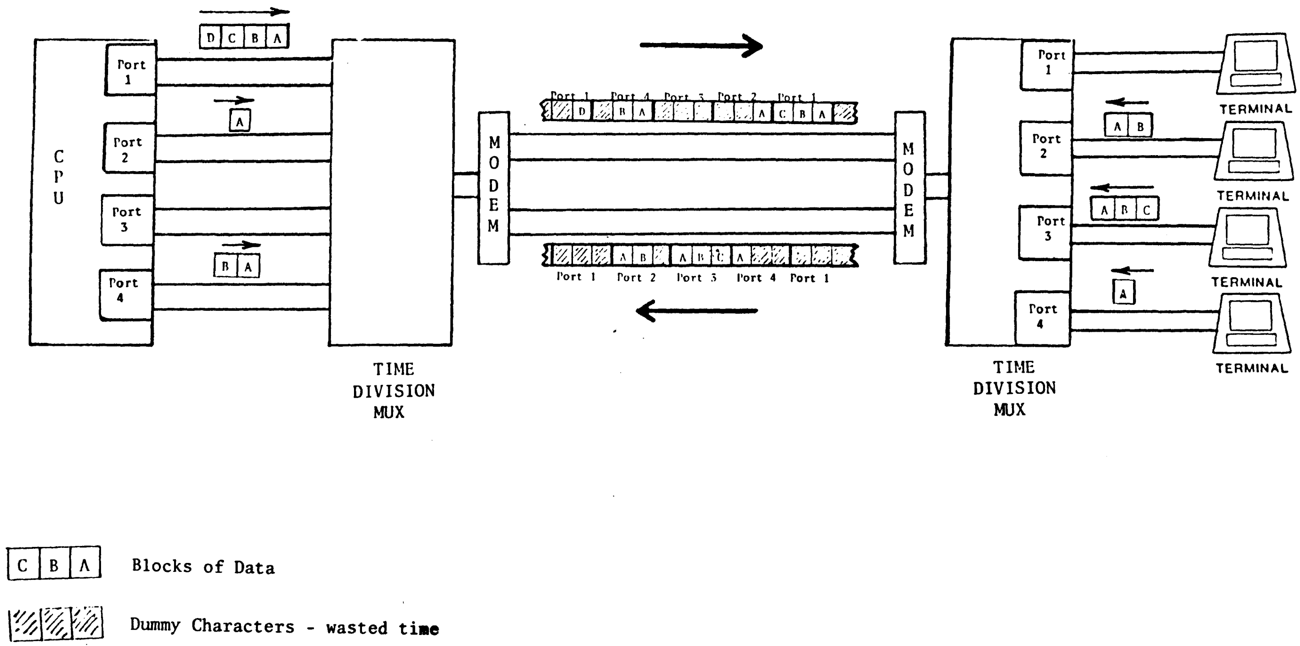
- Typical approach used to link multiple terminal into a CPU located in another city using a single multiplexed line.

- Example: CPU is located in Dallas. Remote terminals are located in New York. One leased line is connected from Dallas to New York. Another short leased line is connected just outside the city limits. Tariff on leased lines is based on distance of line. Therefore, the cost of the short leased line is minimal compared to the long leased line to Dallas. A terminal located in another building places local calls into the multiplexer over the dial up network. Since all four DTE devices are seldom used at the same time, the multiplexers find it very easy to time share data transmission. Even if all DTE devices are connected at the same time, most of the data that is sent is very "Bursty." In most cases, the operator requests screen of information and sends back only a few characters in response to the screen of information. Also the operator normally takes several seconds to several minutes to respond to the screens of information. In short, statistically, each DTE is utilizing the line about 15% of the time. In this set up, a considerable amount of money is saved in leased line costs and long distance calls.

(2) There are three types of multiplexers: Frequency Division, Time Division, and Statistical.

- <u>Frequency Division Multiplexing (FDM)</u> divides up the available band width into smaller bands. A band is then assigned to each device. This technique is only practical with very wide band medias such as are used in Local Area Networks. Frequency division multiplexing several DTE's over a private leased line or a PSTN line is not practical.

- <u>Time Division Multiplexing (TDM)</u> allots a specified amount of time for each DTE port transmit. The specified amount of time for each DTE is fixed. In some TDM's, the allotted amount of time is as small as one bit time. In other TDM's the allotted amount of time may be very long, enough to send a block or several blocks of data. If a terminal has nothing to send during its allotted time "dummy" characters are sent (wasted time). Typically much time is wasted with "dummy" characters."

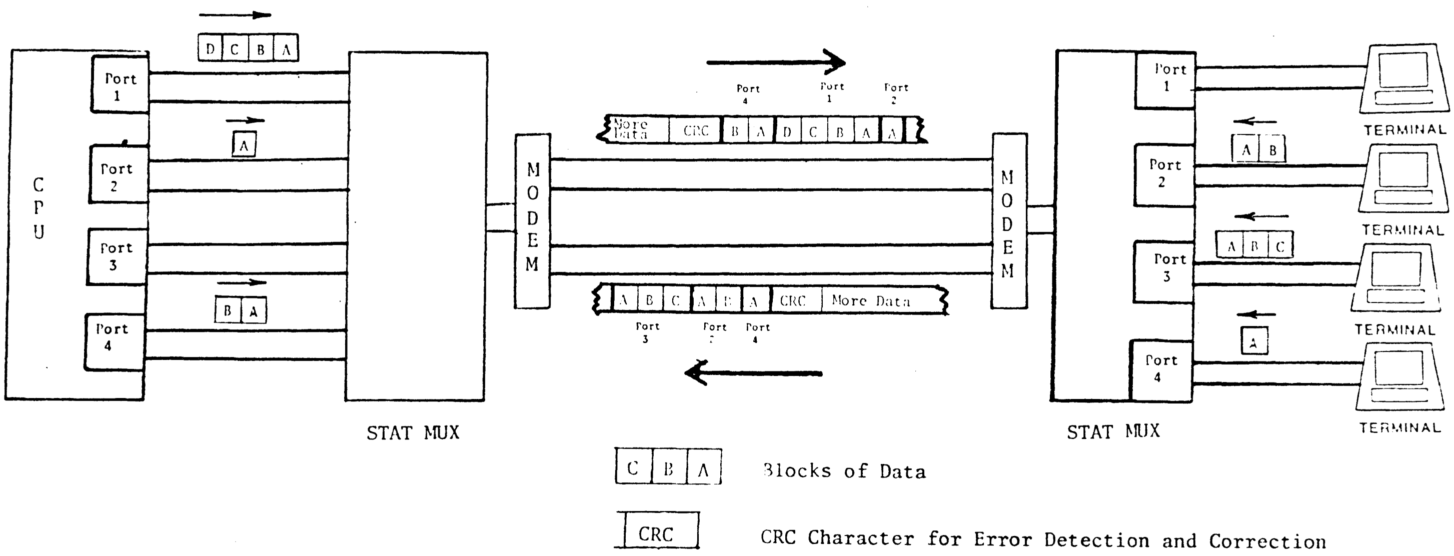


- Each port is allotted three blocks of time for sending data.

- Not all DTE's have three blocks of information to send each time. Therefore, much available transmission time is wasted.

<u>Statistical</u> <u>Multiplexer</u> allows a variable amount of time for each DTE port to transmit. Amount of time allotted for each port varies depending on how much a port has to send. Some ports may have a lot of data to send while other ports may have very little data to send. Data from the DTE ports is first loaded into a buffer. The Statistical Multiplexer then transmits the data from the buffers as required to best utilize available transmission time. Thus, very little of the available transmission time is wasted. This increased efficiency allows the Statistical Multiplexer to have a higher aggregate terminal speed for a given link speed than a Time Division Multiplexer, and still have time to do error detection and correction.

OPERATION OF STATISTICAL MULTIPLEXER



- Amoumt of time allotted for each port is variable.
- Order may be varied.
- Very little time wasted.
- CRC character is sent for error detection and correction.

- Anaology of Time Division Multiplexer and statistical multiplexer.

  <u>Time Division Multiplexer (TDM)</u> - Analogous to restaurant which takes on reservations.
  1. Many tables are empty much of the time.
  2. Total quantity of people served is less.
  3. Cannot overflow. No waiting line.

  <u>Statistical Multiplexer</u> - Analogous to restaurant which does not take reservations.
  1. Most of the tables are full most of the time.
  2. The bar is used a a slack buffer.
  3. Total quantity of people served is greater.
  4. Can overflow. May have waiting line.

(3) Basic Elements of a Statistical Multiplexer

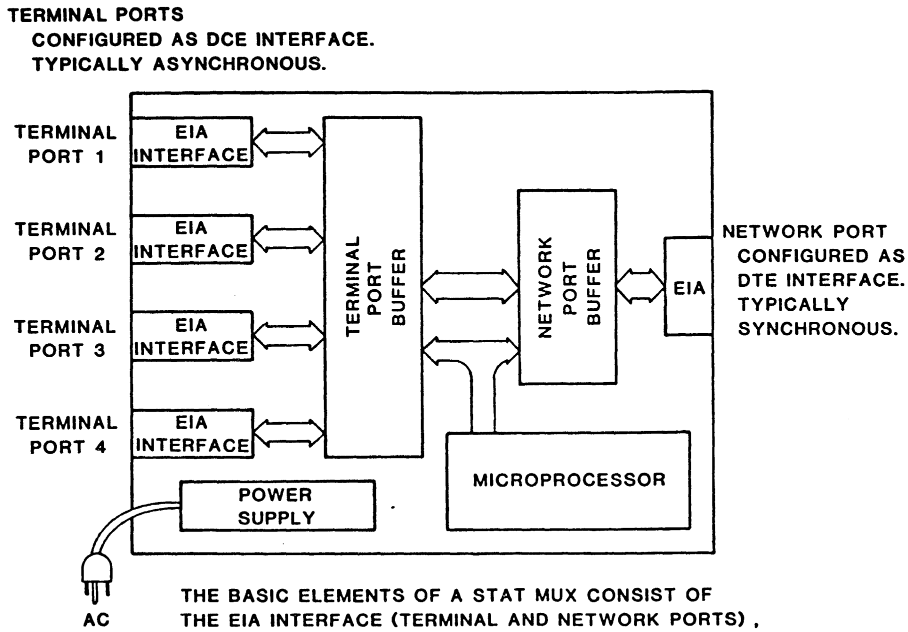
Terminal Port Buffer - solid state memory (RAM) used to hold data coming into and out of the Mux for each terminal port. The buffer is normally dynamically allocated to each of the terminal ports. If data comes into the Mux at a higher rate the network port is able to send it out, the buffer will hold the data until it is 75% full. At this point the Mux will enable flow control, by lowering CTS on sending X-Off character to the terminal on the RD lead. If the terminal does not stop sending data in, the buffer will be destroyed (over written).

<u>Network Port Buffer</u> - solid state memory (RAM) that is used to hold data going into and out of the modem. This buffer is used to create frames of data. In the buffer, the (CRC) is added to permit error detection. This buffer holds incoming frames of data from the modem and checks this BCC character for error. If a frame is found to be in error the Mux requests that the frame be retransmitted by sending a NACK (no acknowledgement) for that frame. If frame has no error, the Mux sends an ACK (acknowledgement) for that frame. The transmitting Mux must hold all outstanding frames that have not been acknowledged. If a received frame does not have any errors, it is broken down and sent to the proper terminal port.

<u>EIA RS232 Interface</u> - There are two sets of interfaces on the multiplexer: the terminal port EIA RS232 Interface and the Network Port (modem) EIA Interface. These are the serial ports used for sending data into and out of the Mux.

<u>MicroProcessor</u> - The controller for the Mux. All buffering, formating, processing, transmitting and receiving is controlled by the Micro Processor.

<u>Power Supply</u> - Converts 120V AC to +5V, +12V, and -12V DC to power Mux.



THE BASIC ELEMENTS OF A STAT MUX CONSIST OF THE EIA INTERFACE (TERMINAL AND NETWORK PORTS), THE BUFFERS, THE MICROPROCESSOR TO CONTROL ALL SYSTEM FUNCTIONS, AND THE POWER SUPPLY.

BASIC ELEMENTS OF A STAT MUX

(4) Flow Control (Data Restraint)

There are two types Flow Control: Internal Flow Control and External Flow Control.

<u>Internal Flow Control</u> - this is the ability of the Stat Mux to stop the terminal from sending data. If the terminal on port one is sending data and the network port is receiving a high number of re-transmit frames due to poor telephone lines, the Mux must tell the terminal to stop sending data when the buffer fills up. This is accomplished by sending an X-Off (DC1) character (inband Flow Control) to the terminal or lowering Clear to Send (CTS, Pin 5) to the terminal (out of band Flow Control). When the buffer reaches a safe level, the Mux will send an X-On (DC3) character or raise Clear to Send (CTS, Pin5) to the terminal. This will allow the terminal to start sending data again.

<u>External Flow Control</u> - this is the type of data restraint that comes from the terminal. It tells the Mux to stop sending to the terminal. An example of this would be a printer that has run out of paper. Since the printer can no longer receive any data until paper has been added, it must tell the Mux to quit sending data. There are three types of External Flow Control: X-Off (DC3) character

sent to Mux (inband Flow Control), X-Off (DC3) character transparent (inband Flow control), and lowering of DTR (Pin 20) or Pin 14 (special pin) to the Mux (out of band Flow Control)

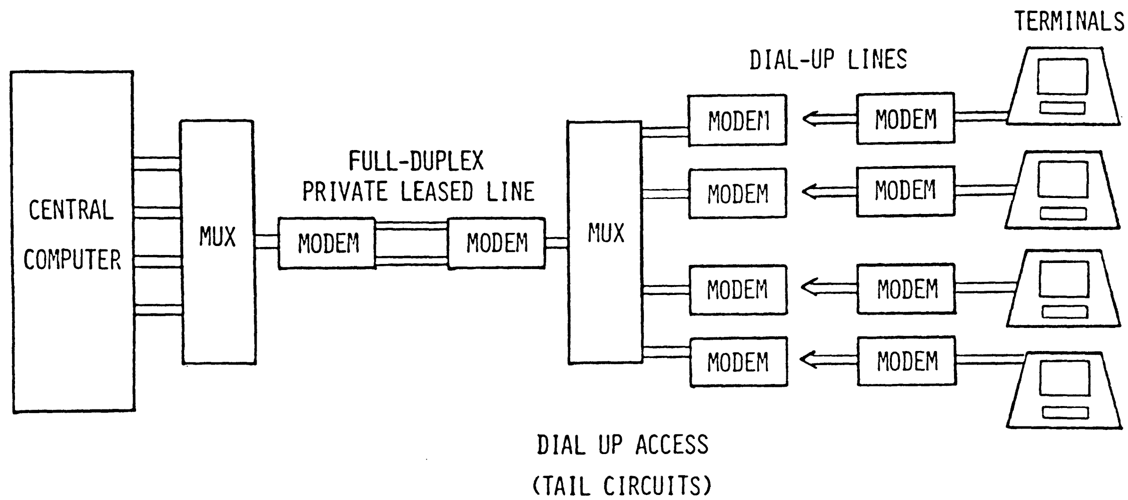
X-Off (DC3) Character to the Mux - inband Flow Control. The terminal sends X-Off (DC3) character to the Mux telling it to quit sending data. The data is stored in the Mux's buffer until the terminal is ready to receive data again. If the buffer in the local Mux fills up, data is restrained from the remote Mux until its buffer fills up also. If the terminal is still not ready to receive data, X-Off is then sent from the remote Mux to the remote terminal.

X-Off (DC3) Transparent - inband Flow Control. When the terminal sends an X-Off character to the Mux, it is transmitted through both Mux's to the remote computer. When the computer receives the X-Off character, it stops sending data. With transparent Flow Control activated, the Mux's do not respond to the X-Off character. They simply pass it through as any other data.

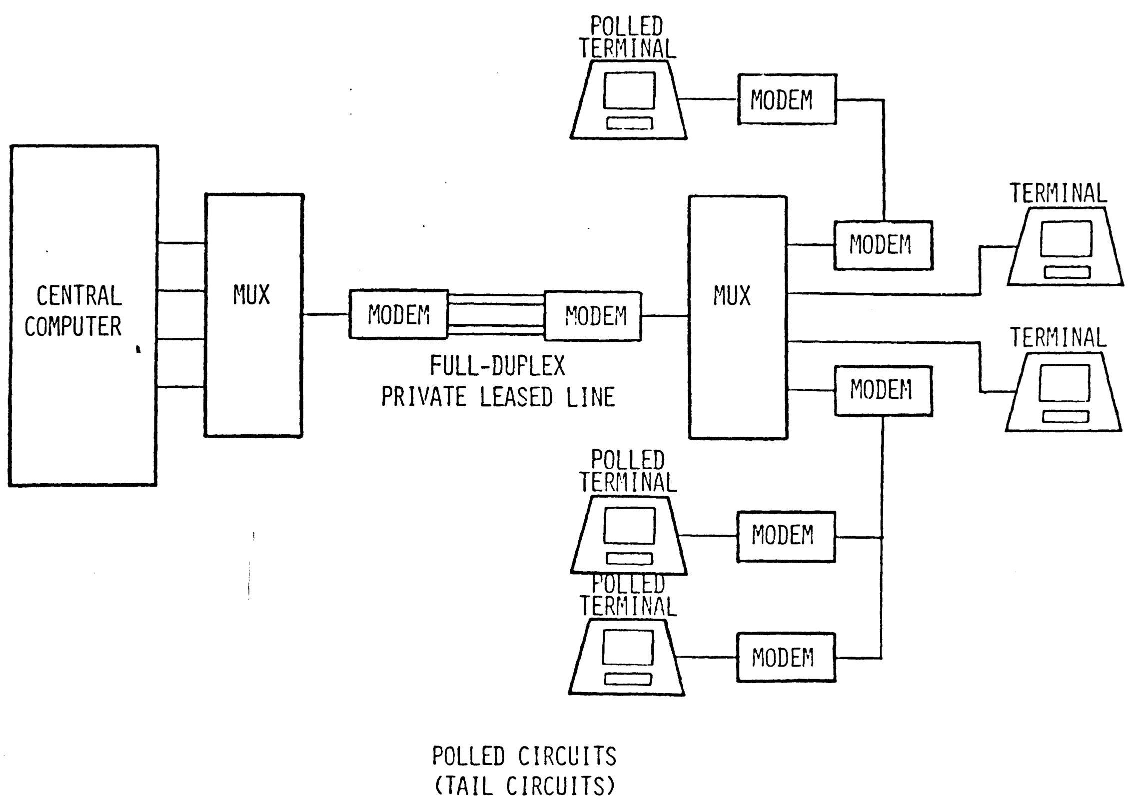
DTR (Pin 20) or Pin 14 (Special Pin Assignment - out of band Flow Control. The terminal lowers DTR (Pin 20) or Pin 14 to the Mux to tell it to stop sending data. Data is restrained in the same way as it was with the X-Off character. When the terminal raises DTR (Pin 20) or Pin 14 to the Mux, it will start sending data again.

(5) Passing Through of EIA Control Signal

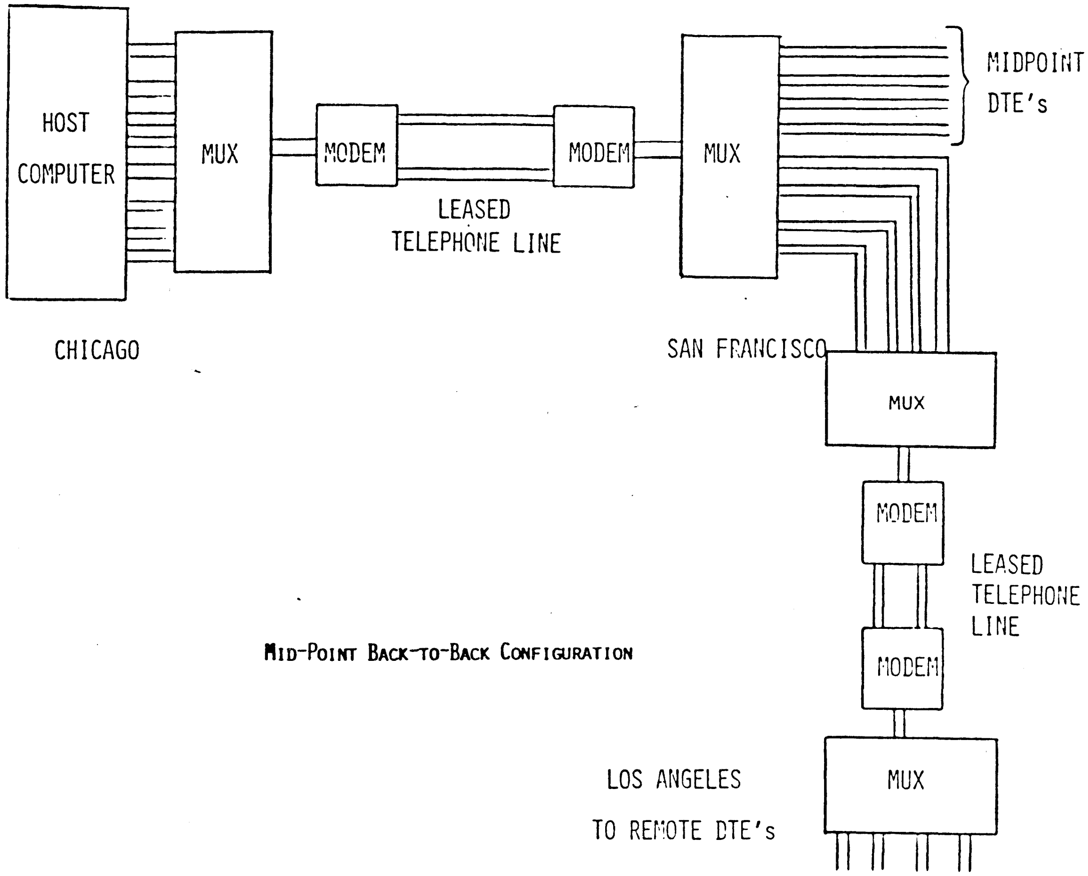
Some Mux's have the capability to pass through some of the RS232 control signals. Typically, Request to Send (RTS), Carrier Detect (CD), Data Terminal Ready (DTR), Data Set Ready (DSR), Make Busy (MB), and Ring Indication (RI) are passed through the Mux. These signals are used to control tail circuit configuration. This permits a local CPU to have full control of a remotely located modem. The transfer of the control lead status is delayed. This is because the Mux encodes, transmits, decodes, and activates the corresponding control leads through modems and the transmission line.



Example of passed through RS232C Control Leads controlling remotely located Dial Up Modems



Example of passed through RS232C Control-Leads controling remotely located Polled Modem (tail circuit)



Example of passed through RS232C control leads controlling remotely located modem in a mid-point back to back configuration.

6. Special considerations when configuring a Statistical Multiplexer System.

- Utilization is the quantity of data that is normally passed between the terminal and the computer. This figure is very important, but in most cases, it is not readily available. Therefore some assumptions must be made.

  - Approximate utilization figures for "dumb" terminal and computer being used interactively.

    Terminal to computer - 2% to 5%
    Computer to terminal - 10% to 15%

  - Assume 25% utilization

    25% = 15% (worse case) +10% (margin)

  - Computer to computer and computer to printer may approach 100% utilization.

- Aggregate Speed - is the sum of all the terminal port speeds.

  Aggregate speed = data rate terminal 1 + data rate terminal 2 + data rate terminal N.

  Example: 4 port Stat Mux with each terminal operating at 2400 bps.

    Aggregate speed = 2400 + 2400 + 2400 + 2400
    Aggregate speed = 9600 bps

- Network (Modem) Port Speed - is speed at which the modem must operate to permit the Stat Mux system to operate properly.

  - Approximate calculation of required network port speed.

    Network port speed = utilization X aggregate speed.

    Network speed = 25% X 9600 bps

    Network speed = 2400 bps.

- This will normally permit the system to operate <u>without</u> Flow Control activated.

- Exact formula for determining Network Port Speed (NPS) for Stat Mux with N Terminal Ports (TP) and known Utilization (U).

  NPS = TP1 (bps) xU1 + TP2 (bps) xU2 + TPn (bps) xUn.

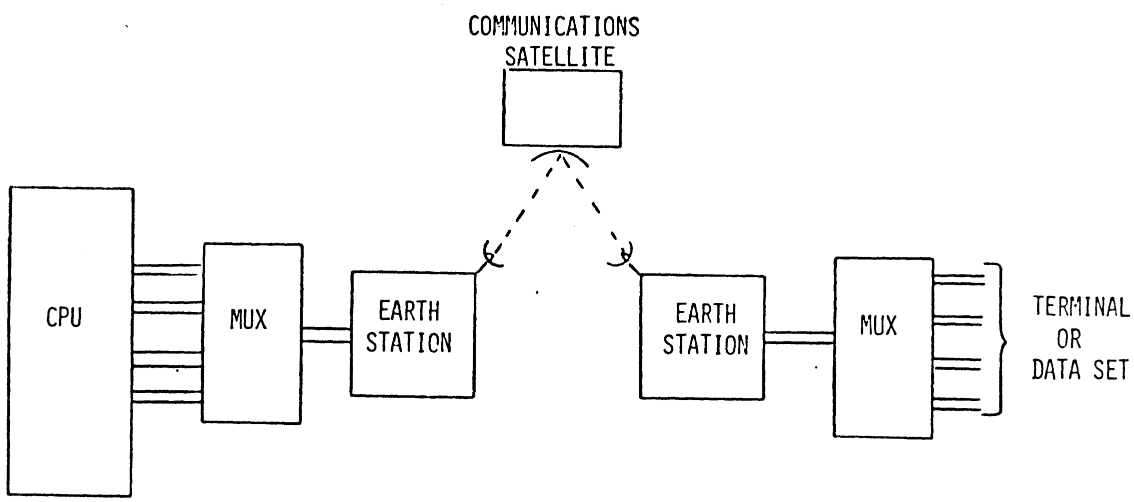
- Always use a modem that is greater than the calculated Network Port Speed.

  Example:
  For calculated Network Port Speed of 3600 bps, use a 4800 bps modem

- If the calculated Network Port Speed is higher than the available modem speed, the speed of the Terminal Ports must be reduced. If this is undesirable, then two Mux's with less ports must be used.

- <u>Caution</u> should be used when connecting Mux's to systems that are computer to computer or computer to printer. These types of equipment tend to "Hog" the system because of their high utilization.

- Most statistical Mux's will not operate properly over Satellite Links because the buffers are typically to small to handle the long delay before acknowledgement. Some Mux's are specifically designed for this purpose.



SATELLITE DATA LINK

VI. Data Link Layer

1. Channel Access Methods
   This layer defines the channel access methods used in networks. These access techniques are the means by which nodes gains use of the network. There are two general categories of access methods - noncontention and contention.

   - Noncontention -- node takes turns accessing the network in or orderly fashion so that collision between nodes is avoided.

   - Contention - nodes access the network randomly. With this method collisions may occur.

2. Polling - is a noncontention method of network access. Polling may be centralized or distributed.

   A. Centralized Polling - polling is controlled by a master or control node. The master asks each node one at a time if it has any information to send. If it does not have information, it responds with a no and goes on to the next node.

   - master node has poll list
   - all nodes listen but only respond to their unique "poll code" or "name"
   - if two devices would speak at the same time there would be a collision
   - the time interval alloted for each nodes response is determined by the message size allowed
   - terminal device (nodes) must be intelligent
   - can be used on any type of topology

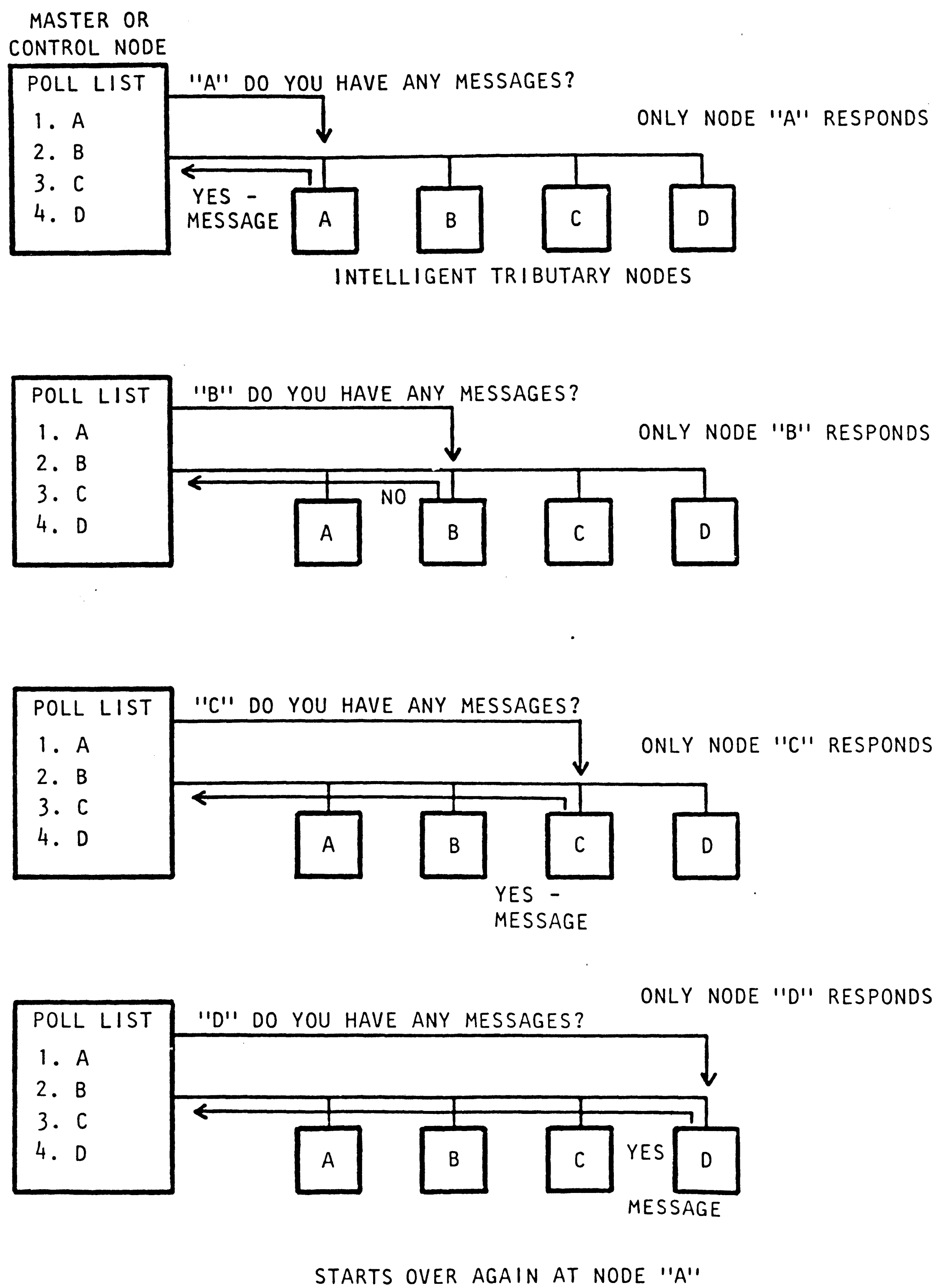
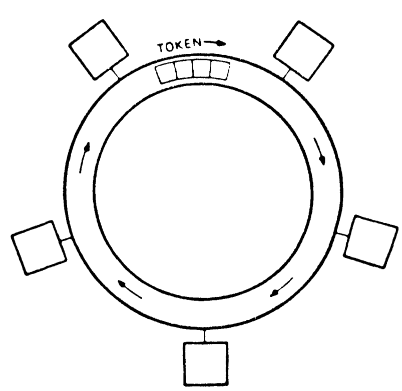


Illustration of Centralized Polling

B. Distributed Polling - polling is not controlled by a central or master node. Polling is controlled by allowing exclusive time slots that a node could transmit in.

(1) Token Passing - a mechanism whereby each device, in turn and in a pre-determined order, receives and passes the right to use the channel.

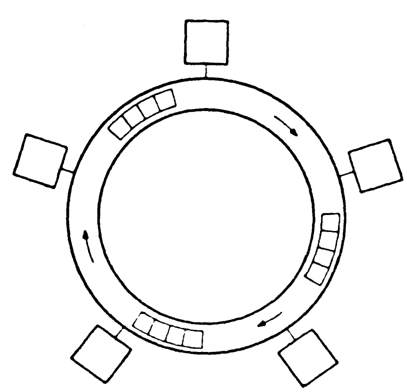
- normally associated with ring topologies.
- may be used on bus topologies
- tokens are special packet or patterns of bits
- tokens are circulated around the ring when there is no message traffic
- possession of the token gives a node exclusive access to the network
- since only one node can have a token there are no conflicts with other nodes that wish to transmit
- a node that wishes to transmit a message will hold the token and send a message to a specified address
- each node will identify and accept messages addressed to it
- each node will repeat and pass on messages not addressed to that node
- when the message is received back by the sending node, it removes the message and passes the token on
- the same node cannot use a token twice in a row. This prevents "Hogging" of the channel.



Token Passing

(2) Slotted Rings - a mechanism where by several devices may transmit messages in turn by using several tokens that are passed around the ring at the same time. In the method of token passing, a number of slots or frames of fixed sized circulate around the ring.

- each frame contains source and destination address, control and parity information, and data.
- when a node wants transmit, it waits for a free or unused slot, inserts data into the appropriate field, and sets a bit to indicate that the frame is full. The source and destination addresses are specified.
- when the destination node receives the frame, it copies the data and sets a bit to indicate the frame is empty. Another node can now use this empty frame for transmission.
- frames that are addressed to other nodes are passed on.
- one node is normally designated to place the original frame in circulation.



Slotted Ring

(3) Carrier Sense Multiple Access with Collision Detect (CSMA/CD) - is a contention method of network access where any node may transmit a message upon sensing the channel is free of traffic.

(A) Carrier Sense (listen-before-talking) - the ability of each node to detect any traffic on the channel.

- nodes may not transmit whenever they sense traffic on the channel.
- nodes may transmit whenever they sense no traffic on the channel.
- because of propagation dalay two nodes could detect that the channel is free either exactly at or close to the same time, yet not detect each other. In this situation, a collision between the two messages will occur.

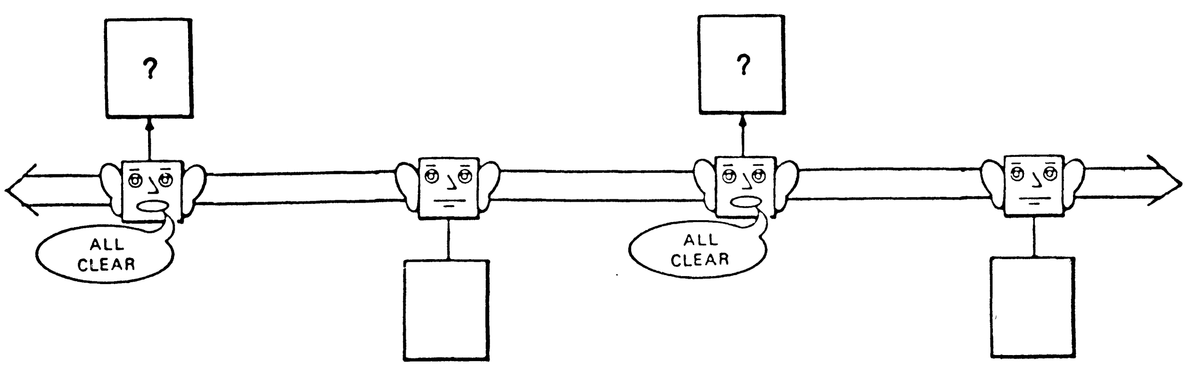


Illustration of Carrier Sense Multiple Access

Listen before talking to avoid collisions.
Two devices may sense the channel is clear at the same time.

(B) Multiple Access - permits any node to send a message upon sensing that a channel is free of traffic.

- more efficient use of channel time because there is no waiting.

(C) <u>Collision</u> <u>Detection</u> - the ability of a transmitting node to sense a change in the energy level of the channel and to interpret it as a collision.

- upon detecting a collision, each node involved <u>backs</u> <u>off</u> and abandons its transmission, waits for a brief interval, and attempts to transmit again.
- the interval of back off may be fixed, random or controlled by algorithm (wait longer each time a collision occurs).
- <u>Jam</u> - a short burst of noise emitted by the collision nodes to ensure that all nodes involved have detected the collision.
- to ensure that all nodes are able to hear a collision, the slot time (size) of each packet must be slightly greater than the round trip propagation delay **between the two farthest points in the network.**

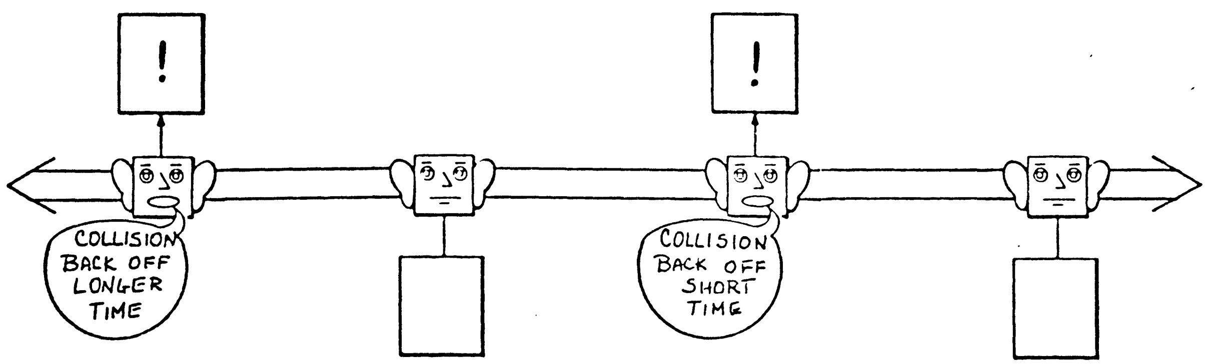


Illustration of Collision and Back Off

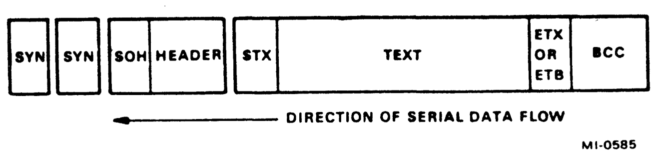
Analogy - group of polite people standing around talking.

- if one person wants to speak and nobody else is talking, he simply speaks
- if someone else is talking, he waits for them the finish
- when two people begin talking at the same time they both stop talking (back off), and then randomly start talking again
- eventually one person will speak before the other gains access to the floor

3. Data Link Protocols

(A) Bisync Link Protocol

- Characteristics
  - older IBM protocol (1968)
  - used for HDX Multidrop Polled Networks
  - character-oriented, i.e., uses special control characters and delimiters
  - each block must be acknowledged before the next block is sent (HDX)
  - several LSI chips handle bisync (8251)



BISYNC Message Format

- **Message Format**

  - optional header is user-defined
  - DLE around text makes it transparent as it turns off receiver character recognition
  - acknowledgement with ACKO, ACK1, WACK OR NAK and sent via separate control messages
  - block check codes are VRC for ASCII, CRC-16 for EBCDIC, and CRC-12 for transcode

  - SOH - Start of Header
  - STX - Start of Text
  - ETB - End of Transmission Block
    ETB indicates the end of a block of characters that started with SOH or STX and indicates that the block check is coming next. ETB requires a response from the receiving station indicating its status: ACKO, ACK1, NAK, WACK, or RVI.

  - ITB - End of Intermediate Transmission Block (This is called IUS in EBCDIC and US in ASCII)

    ITB is used to separate the message into sections for error detection purposes without causing a reversal of transmission direction. The transmission of ITB indicates that the block check is coming next. While the block check is checked at this point and reset to zero, the receiving station does not reply to the transmitting station until a final block, ending the ETB or EXT, is received. Except for the first intermediate block, or a boundary between a heading block and a text block, the intermediate blocks need not begin with STX. One further exception is the use of intermediate blocks in transparent data transfer - these must all start with DLE STX.

- ETX - End of Text
  Terminates a block of characters transmitted as an entity and which started with SOH or STX. Its function is the same as ETB except that it also means that there are no more data blocks to be sent.

- EOT - End of Transmission
  EOT indicates the end of a message transmission which may contain a number of blocks, including text and headings. EOT is also used to respond "nothing to transmit" to a polling request and can also be used as an abort signal.

- NAK - Negative Acknowledgement
  NAK indicates that the previous block was received in error.

- DLE - Data Link Escape
  One of the uses of DLE is in the creation of WACK, ACKO, ACK1, and RVI, which are two-character sequences. As an example, in EBCDIC RVI is sent as DLE@. DLE is primarily used for control character sequences in transparent data transfer. The sequence DLE STX is used to initiate transparent text and DLE ETX, DLE ITB, and DLE ETB are used to terminate transparent text. In addition, DLE, ENQ, DLE DLE, and DLE EOT are also used for control purposes during transparent text transmission.

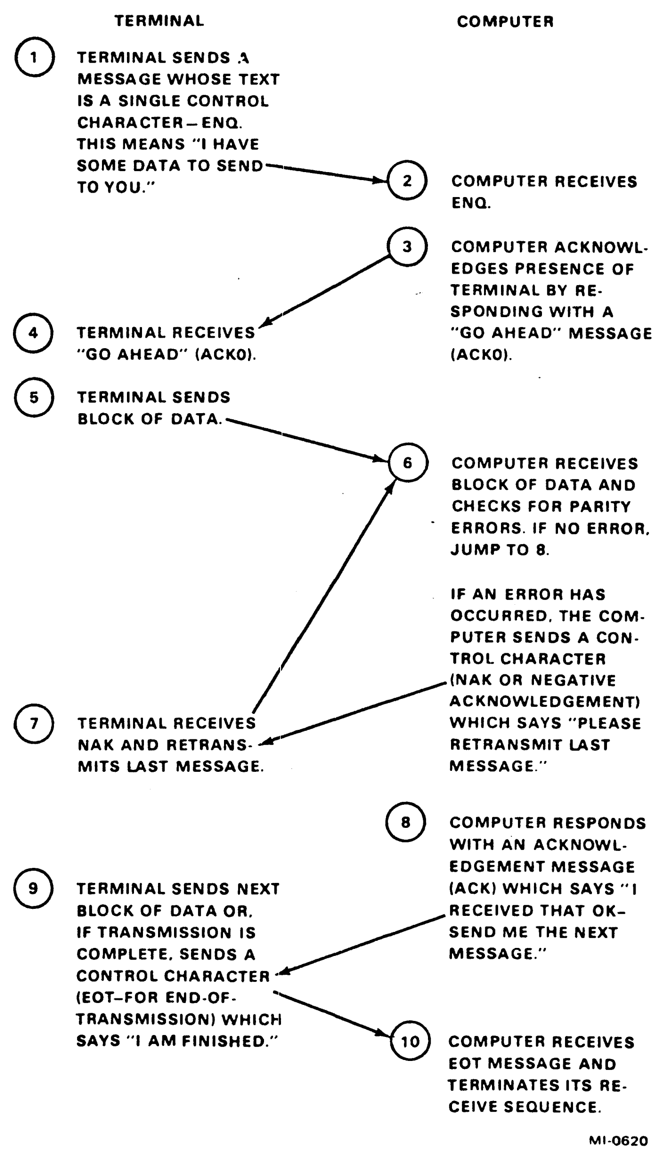
- ENQ - Enquiry
  ENQ is used to bid for the line when using point to point connections; it indicates the end of a poll or selection sequence. It is also used to request retransmission of the ACK/NAK response if the original response was garbled or not received when expected.

- ACKO, ACK1 - Affirmative Acknowledgement
  These replies indicate that the previous block was accepted without error, and that the receiver is ready to receive the next block. ACKO is used to acknowledge multipoint selection, point-to-point line bid, and even numbered blocks. ACK1 is used to acknowledge odd numbered blocks.

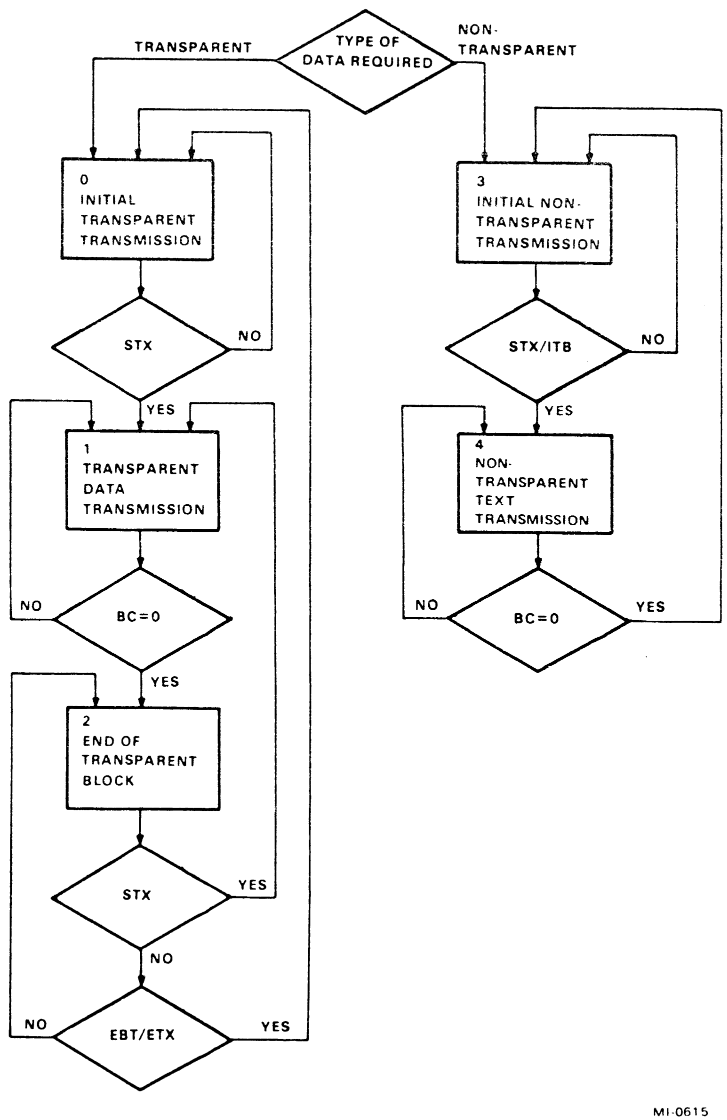
- WACK - Wait Before Transmit Positive Acknowledgement
  A WACK reply indicates that the previous block was accepted without error, but that the receiver is not ready to receive the next block. The usual response from the transmitting station is ENQ and the receiving station continues to respond with WACK until it is ready to receive.

- RVI - Reverse Interrupt
  Like ACKO, ACK1, and WACK, RVI is a positive acknowledgement. However, it is also a request that the transmitting station terminate the current transmission as the receiving station has a high priority message which it wishes to send to the transmitting station and thus needs to turn the line around.

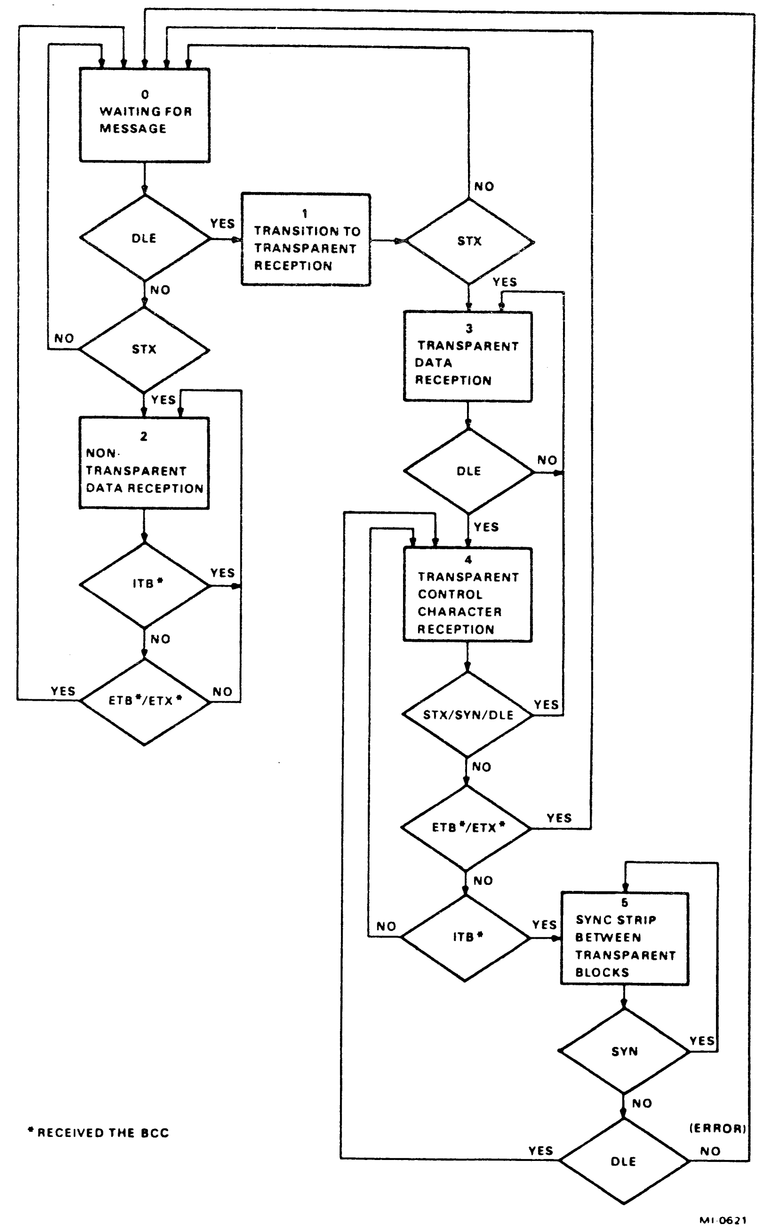
- TTD - Temporary Text Delay (STX ENQ)
  TTD is used by a transmittig station which is not quite ready to transmit, but wishes to retain the line. The receiving station responds with NAK and the transmitting station may again send TTD if it is still not ready.



Typical Data Exchange Using BISYNC



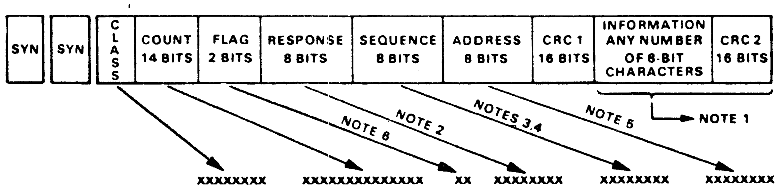
BISYNC Transmission Flow Diagram



BISYNC Reception Flow Diagram

B. DDCMP Link Protocol

- Characteristics
  - DEC protocol for mini computer network
  - provides transparency using byte counts, thus a byte-oriented protocol
  - works for synchronous/asynchronous, HDX/FDX, point-to-point/multi-point network links



Data Messages	10000001	Character Count	QS	Resp #	Message#	Address
Acknowledgement	00000101	00000001000000	QS	Resp #	00000000	Address
Negative Acknowledge	00000101	00000010-------	QS	Resp #	00000000	Address

Reasons:	BCC Header Error	000001
	BCC Data Error	000010
	Rep Response	000011
	Buffer Unavailable	001000
	Receiver Overrun	001001
	Message Too Long	010000
	Header Format Error	010001

Reply Message	00000101	00000001100000	QS	00000000	LstMess#	Address
Start Message	00000101	00000110000000	11	00000000	00000000	Address
Start Acknowledgement	00000101	00000111000000	11	00000000	00000000	Address
Maintenance Message	10010000	Character Count	11	00000000	00000000	Address

Notes:

1. Only the Data Message and the Maintenance Message have character counts, so only these messages have the information and CRC2 fields shown in the message format diagram above.
2. "Resp #" refers to Response Number. This is the number of the last message received correctly. When used in a negative acknowledge message, it is assumed that the next higher numbered message was not received, was received with errors, or was unaccepted for some other reason. See "Reasons."
3. "Message#" is the sequentially assigned number of this message. Numbers are assigned by the transmitting station modulo 256; i.e., message 000 follows 255.
4. "LstMess#" is the number of the last message transmitted by the station. See the text discussion of REP messages.
5. "Address" is the address of the tributary station in multipoint systems and is used in messages both to and from the tributary. In point to point operation, a station sends the address "1" but ignores the address field on reception.
6. "Q" and "S" refer to the quick sync flag bit and the select bit. See text.

MI-0657

DDCMP Message Format in Detail

C. HDLC/SDLC Link Protocol

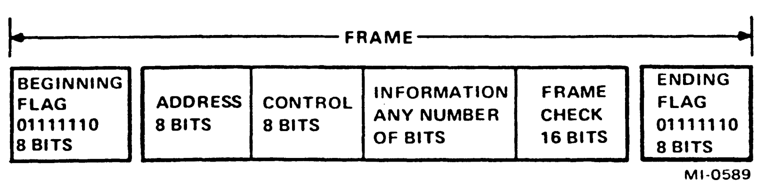
- Characteristics

  - SDLC is standard IBM protocol, while HDLC is CCITT extension of SDLC
  - many other protocols are similar to SDLC
  - provides transparency with bit stuffing, thus is a bit oriented protocol
  - bit stuffing avoids the unique flag byte 01111110

DATA	TxDATA	RxDATA
00111111111	0011111<u>0</u>1111	0011111~~0~~1111
0011111010	0011111<u>0</u>010	0011111~~0~~010
	inserted	removed

  thus, pattern 01111110 cannot occur in TX DATA
  - idle character is flag byte
  - pattern of ≥ 7 continuous 1's means abort
  - pattern of ≥ 15 continuous 1's means terminate polled connection
  - there is a SDLC variation for loop networks that operates much like "token passing"

- SDLC Message Frame Format



Basic SDLC Frame

  - flags delineate the message frame
  - address field can be extended
  - information field can be any length
  - bit-stuffing is applied between flags

- Control Field

  - determines type (function) of frame

	0	1	2	3	4	5	6	7
Information frames	N (R)			P/F	N (S)			0
Supervisory frames	N (R)			P/F	SUPV		0	1
Unnumbered frames	M			P/F	M		1	1

Where:

N(S) – Sequence number of the frame containing this control field

N(R) – Sequence number of the next frame the transmitter expects to receive

P/F – Poll/Final bit (Primary sets Poll, Secondary sets Final)

SUPV– Up to four supervisory functions

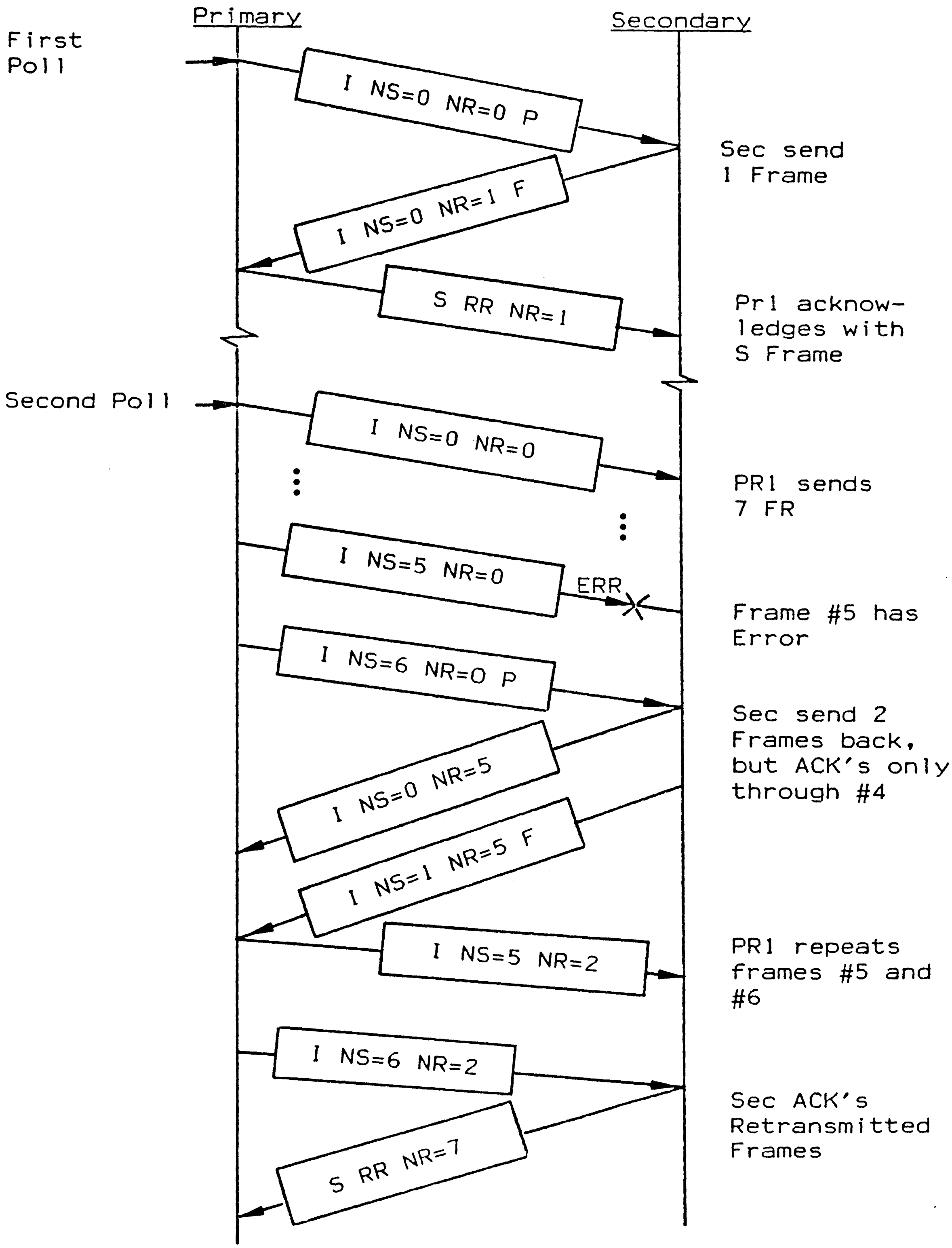
M – Additional link control functions

Frame Control Field, in Detail, (Listed by Frame Type)

  - poll/final bit indicates poll from primary (master) and final frame when from secondary (slave)
  - sequence numbers indicate last frame sent and next expected
  - I frames contain normal data information
  - S frames initiate and control flow of I frames
  - U frames are for disconects, unusual situations, and to provide additional link control functions

- Supervisory Commands
  - Receive Ready (RR) – acknowledges frames through NR and indicates ready for frame NR next
  - Reject (REJ) – requests retransmission of frame NR and all following frames
  - Receive Not Ready (RNR) – stop sending temporarily, but resume with frame NR when clear
  - Selective Reject (SREJ) – request retransmission of the single frame NR, and acknowledges frames NR-1 (will not accept later frames until NR recieved)

HDLC Polling in HDX



intel

PRELIMINARY

8274 MULTI-PROTOCOL SERIAL CONTROLLER (MPSC)

- Asynchronous, Byte Synchronous and Bit Synchronous Operation
- Two Independent Full Duplex Transmitters and Receivers
- Fully Compatible with 8048, 8051, 8035, 8088, and 8086 CPU's; 8257 and 8237 DMA Controllers; and 8089 I/O Proc.
- 4 Independent DMA Channels
- Baud Rate: DC to 880K Baud
  —Future Selections to 1M Baud
- Asynchronous:
  —5-8 Bit Character; Odd, Even, or No Parity; 1, 1.5 or 2 Stop Bits
  —Error Detection: Framing, Overrun, and Parity
- Byte Synchronous:
  – Character Synchronization, Int. or Ext.
  – One or Two Sync Characters
  – Automatic CRC Generation and Checking (CRC-16)
  – IBM Bisync Compatible
- Bit Synchronous:
  – SDLC/HDLC Flag Generation and Recognition
  – 8 Bit Address Recognition
  – Automatic Zero Bit Insertion and Deletion
  – Automatic CRC Generation and Checking (CCITT-16)
  – CCITT X.25 Compatible

The Intel® 8274 Multi-Protocol Series Controller (MPSC) is designed to interface High Speed Communications Lines using Asynchronous, IBM Bisync, and SDLC/HDLC protocol to Intel microcomputer systems. It can be interfaced with Intel's MCS-48, -85, -51; iAPX-86, and -88 families, the 8237 DMA Controller, or the 8089 I/O Processor in polled, interrupt driven, or DMA driven modes of operation.

The MPSC is a 40 pin device fabricated using Intel's High Performance HMOS Technology.

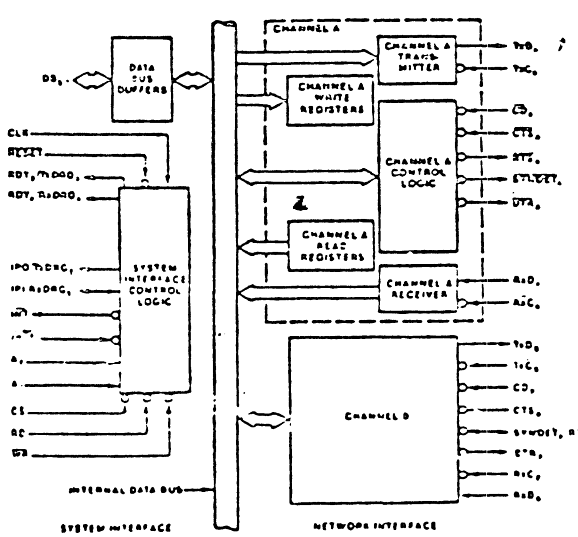


Figure 1. Block Diagram

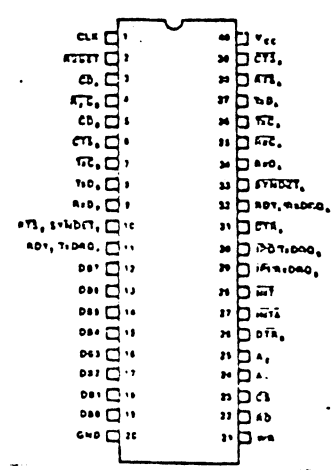


Figure 2. Pin Configuration

Block Error Check Codes

- Parity Codes
  - odd parity adds a 1 or 0 bit to a character so that the total number of 1's is odd
    e.g.,

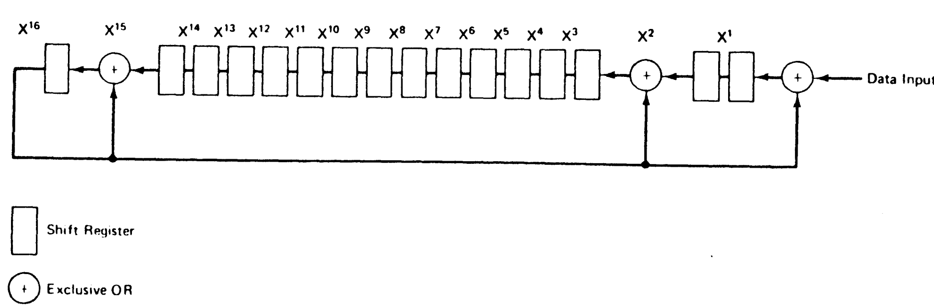
    0111010 → 01110101   Parity bits
    0101010 → 01010100

  - can also form blocks of characters (each with character parity) and generate vertical parity bits i.e., longitudinal redundancy check

0111010	1
0110010	0
0101010	0
0110011	1
1111111	0
0010001	1

  - LRC detects double bit errors and corrects single bit errors

- Cyclic Redundancy Codes (CRC)
  - mod 2 division of data stream by generator polynomial
  - attach division remainder to end of data as check block
  - efficient to implement in hardware or software
  - detects all single and double bit errors, all odd bit errors, all burst errors shorter than generator polynomial, and most other bursts
  - CRC-16 polynomial $Gr(x) = X^{16} + X^{15} + X^2 + 1$



Generation and Detection of the CRC-16 Cyclic Code

VII Network Layer

1. SNA Network Protocol

- Characteristics
  - IBM System Network Architecture (1974) to provide uniform networking for IBM products
  - path control includes some transport and network services
  - uses SDLC for link protocol
  - designed for 370 host running VTAM and 3705 FSP running NCP/VS, etc. (IBM Standard)

- Routing
  - Network closes session route dynamically from route tables
  - virtual route between sub-areas, then explicit routes within sub-areas
  - packets are resequenced before leaving each sub-area
  - packets may be combined temporarily on intermediate routes to increase efficiency

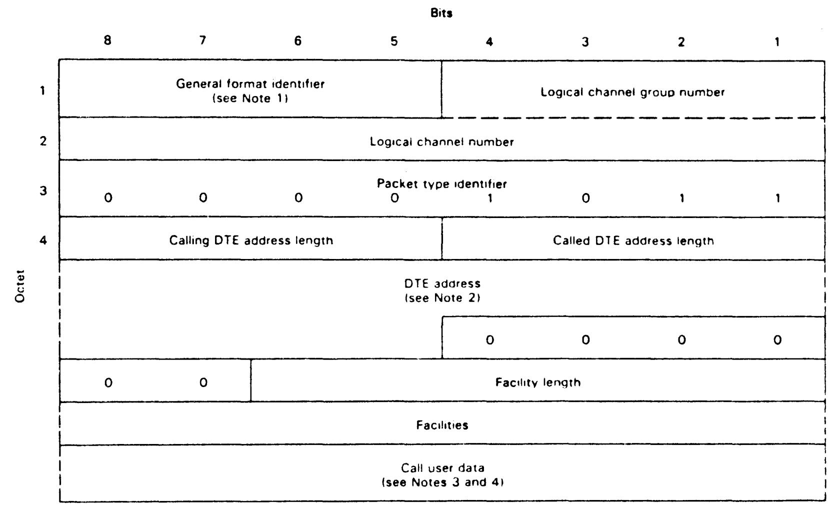
- Flow Control
  - sender initially sends "window" of n packets, which may include a request to send n more
  - receiver returns authorization for n packets when it has sufficient buffer space ("reservation")
  - congestion control done dynamically by adjusting the pacing window parameter n

2. X.25 Network Protocol

- Characteristics

  - ISO/CCITT Standard (1976) for connecting subscriber machines (DTE) to intelligent packet network machines (DCE)
  - widely used throughout the world
  - being slowly adopted in U.S. (Telenet, Tymenet, IBM, DG, DEC, ACS) Honeywell, AT&T
  - uses HDLC for link level protocol and X.21 (X.21 bis) for physical level
  - character-oriented terminal interface via packet assembly/disassembly (PAD) unit, which provides buffering, control, and packetization (X.3, X.28, X.29)
  - network protocol deals with the set-up, use, and clearing of virtual circuits, along with various error procedures
  - distinguishes virtual calls and permanent virtual circuits

- Basic X.25 Packet Format



Note 1 – Coded 0X01 (modulo 8) or 0X10 (modulo 128).

Note 2 – The figure is drawn assuming a single address is present consisting of an odd number of digits.

Note 3 – Bits 8 and 7 of the first octet of the *call user data* field may have particular significance (see § 6.2.1).

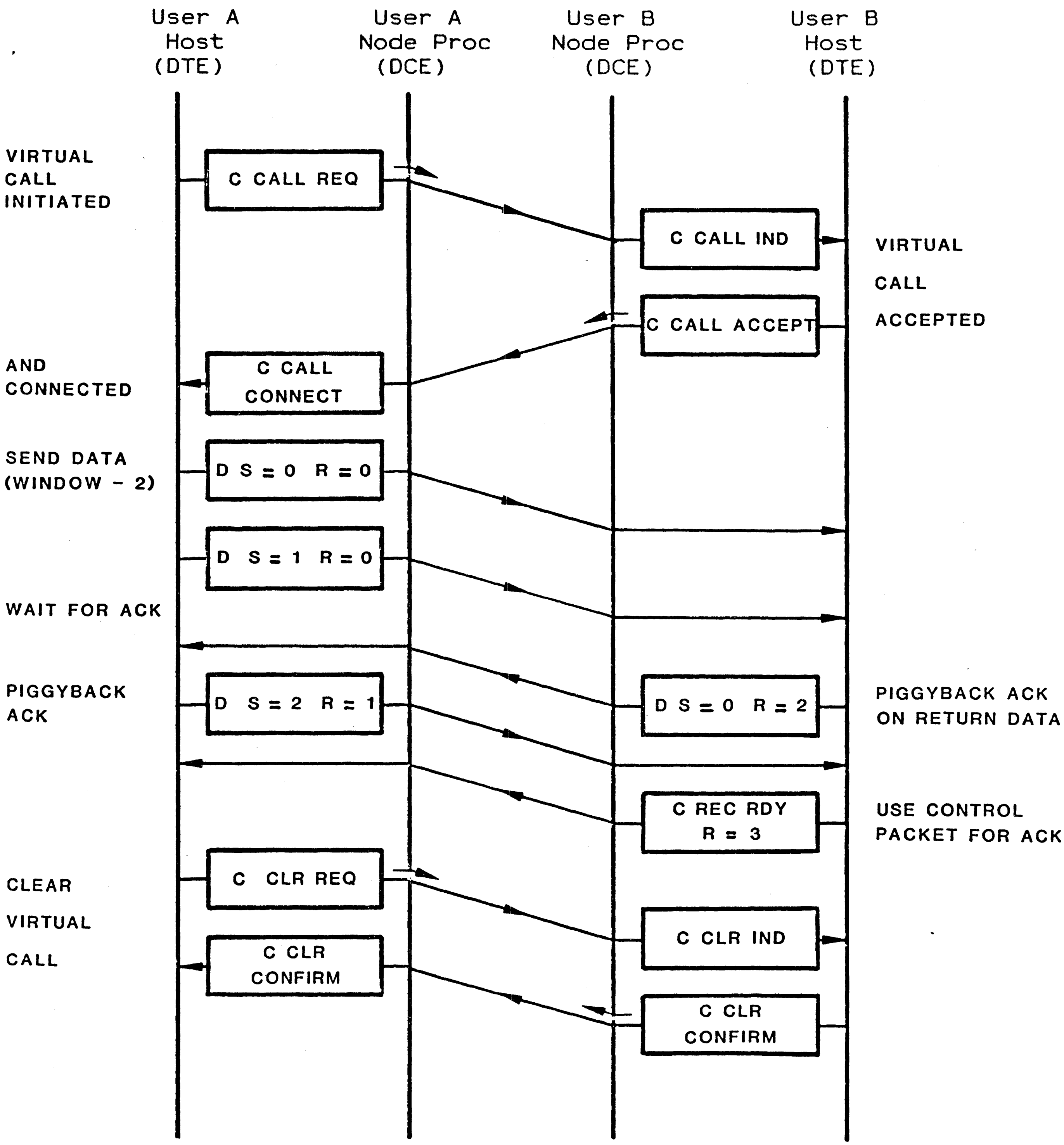
Note 4 – Maximum length of the *call user data* field is 16 octets.

- whole packet goes into HDLC frame as data
- general format identifier specifies sequence counts of 8 on mod 128, and also has 2 bit for intermediate/end-to-end acknowledgements
- logic channel numbers are converted by nodes from virtual calls to physical addresses
- type bits indicate data on control packets, and flag bit for additional control bytes and/or send and receive sequence numbers
- additional control bytes can indicate addresses, special facilities for additional virtual circuit features, e.g., priorities, reverse billing

- X.25 Flow Control
  - sliding window of length n allows no more than n unacknowledged packets at any time
  - n can be adjusted dynamically as the network loading changes
  - large windows are needed for satellite links

- Error Control Packets
  - INTERRUPT and INTERRUPT CONFIRMATION packet pre-empt sequence numbers and one bit of control data directly to the destination
  - RESET packets reinitialize virtual circuits (all sequence numbers, windows, counters, etc.) but circuit remains connected.
  - RESTART packets disconnect (non-permanent) virtual call circuits and reset (permanent) virtual circuits

X.25 Call Procedure



8273, 8273-4, 8273-8
PROGRAMMABLE HDLC/SDLC PROTOCOL CONTROLLER

- CCITT X.25 Compatible
- HDLC/SDLC Compatible
- Full Duplex, Half Duplex, or Loop SDLC Operation
- Up to 64K Baud Synchronous Transfers
- Automatic FCS (CRC) Generation and Checking
- Up to 9.6K Baud with On-Board Phase Locked Loop
- Programmable NRZI Encode/Decode
- Two User Programmable Modem Control Ports
- Digital Phase Locked Loop Clock Recovery
- Minimum CPU Overhead
- Fully Compatible with 8048/8080/8085/8088/8086 CPUs
- Single +5V Supply

The Intel® 8273 Programmable HDLC/SDLC Protocol Controller is a dedicated device designed to support the ISO/CCITT's HDLC and IBM's SDLC communication line protocols. It is fully compatible with Intel's new high performance microcomputer systems such as the MCS-80/86™. A frame level command set is achieved by a unique microprogrammed dual processor chip architecture. The processing capability supported by the 8273 relieves the system CPU of the low level real-time tasks normally associated with controllers.

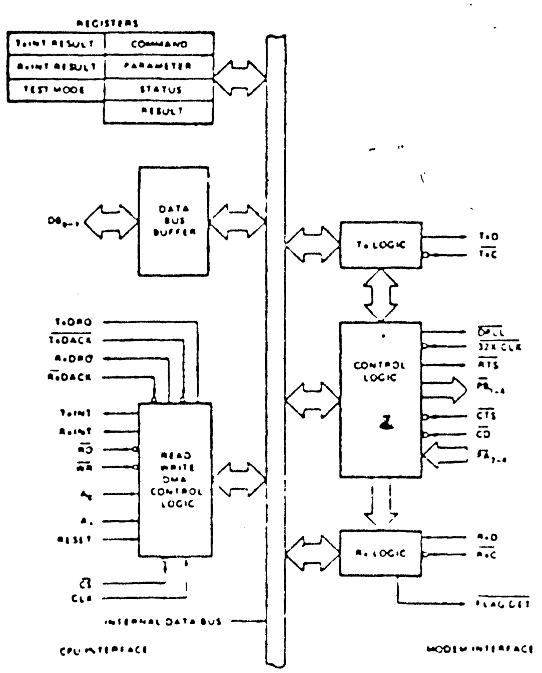


Figure 1. Block Diagram

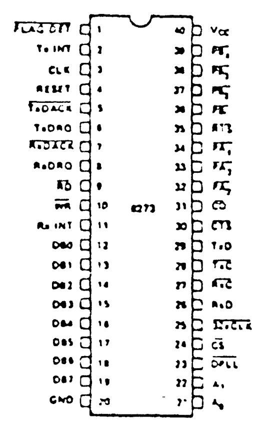


Figure 2. Pin Configuration

Datagrams

- Definition
  A datagram is a single packet message with its own address, and is sent independent of any other messages

Type	Addr	User Data

- Comments
  - avoids overhead of virtual calls
  - a large percentage of day-to-day traffic could be sent as datagrams
  - no sequencing is required
  - by passes lower level X.25 protocols
  - terminals can be simple
  - users must provide all error control
  - undeliverable datagrams are returned to sender
  - address is changed from receiver to sender by network during transmission
  - now specified as part of X.25 standard

VIII. Local Area Network Approaches

There are three popular technologies used for local area networks: baseband, broadband, private branch exchange (PBX)

1. <u>Baseband</u> <u>Approach</u> <u>(Ethernet)</u>
   - designed by Digital Equipment Corporation, Xerox Corporation, and Intel Corporation in 1980. They combined their experience in areas distributed processing, networking communications and VLSI technology.

   A. Physical Layer

      Topology: bus, in the shape of a branching tree.
      Medium: shielded coaxial cable
      Signaling: manchester encoded digital baseband
      Data Rate: 10M bps
      Maximum Seperation of Nodes: 2.8Km (about 1.7 miles)
      Maximum number of Nodes: 1,024

   B. Data Link Layer

      Network Control: multiaccess - evenly distributed to all nodes

      Access Control: carrier sense multiaccess with collision detection

      Allocation: packet length from 64 to 1518 bytes. Data field 46 to 1500 bytes

C. Maximum Ethernet Configuration

- A segment of coaxial cable can be a maximum of 500 meters in length. Each segment of coaxial cable is terminated at both ends, at which point transmitted signals stop.

- There can be a maximum of 100 nodes connected to any segment of the cable, and nodes must be at least 2.5 meters apart on the cable segment.

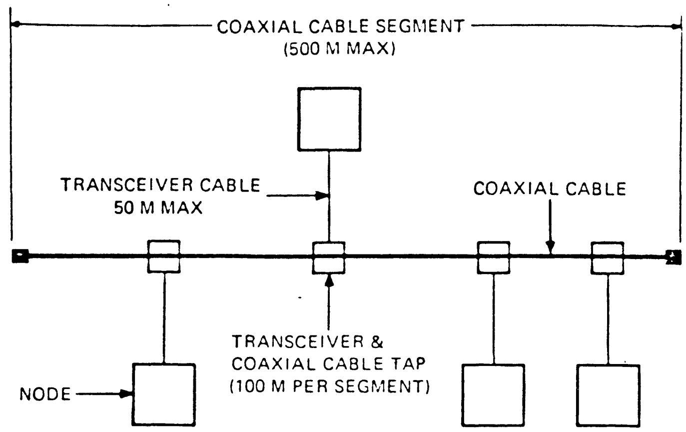
  A node is a single addressable entity on the Ethernet that is connected via a cable tap. transceiver, and a controller. (Remember, a number of devices can be connected to one node).

- Repeaters are used to continue signals from one segment of the Ethernet to another. A maximum of two repeaters can be placed in the path between any two nodes. A repeater requires a transceiver connection (a node "position") on both of the segments it joins and counts towards the 100 node maximum for each segment.

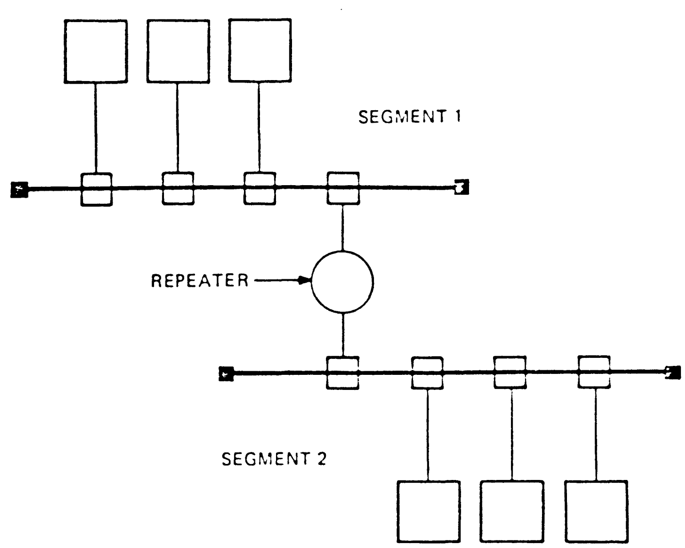
  Repeaters can be placed at any or every available node position on a cable segment (up to 100) and can be used to extend the network topology from one to three dimensions.

- The maximum length of coaxial cable between any two nodes is 1,500 meters.

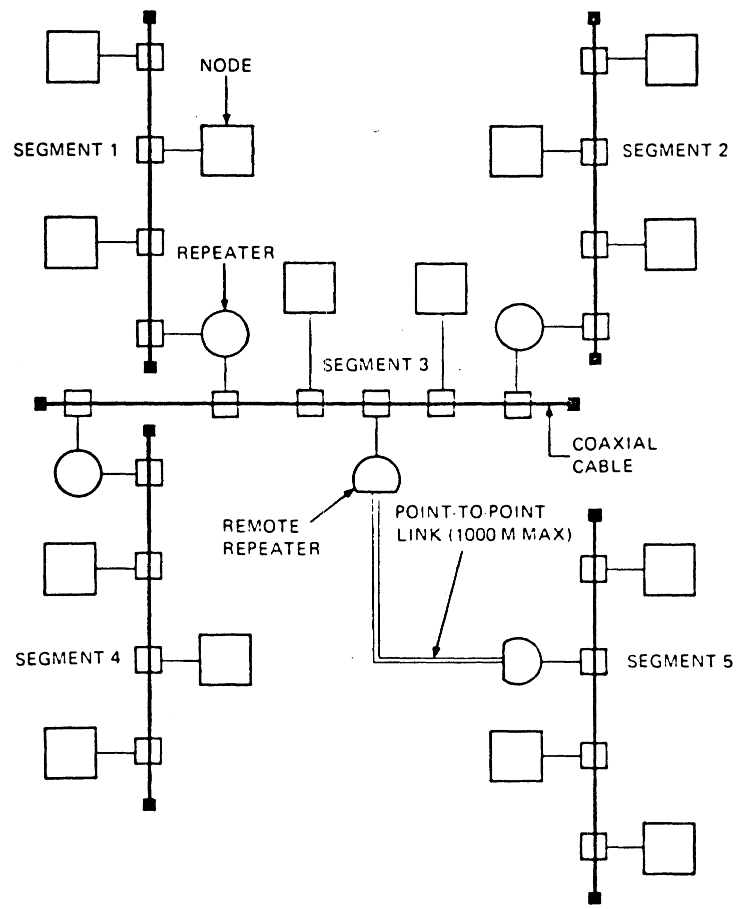
- The maximum length of the transceiver cable (between a transceiver and the controller) is 50 meters.
- The maximum of 1,000 meters of point-to-point link is allowed for extending the network - for instance between two buildings. (One possible implementation would be to connect two Ethernet segments, using a high-speed, point-to-point, fiber optic link).
- The 2,800 meter maximum end-to-end length of the network between any two nodes is the sum of three 500-meter coaxial cable segments plus six 50-meter transceiver cables plus 1,000 meters of point-to-point link.



Small Ethernet Configuration

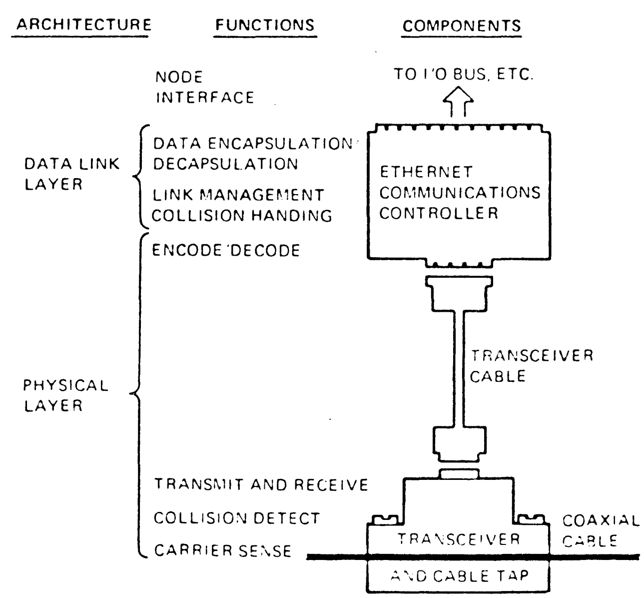


Medium-Scale Ethernet Configuration



Large-Scale Ethernet Configuration

Interface to Ethernet



D. Packet Format for Ethernet

(1) Preamble and Interframe Spacing

- 64 bit preamble for synchronization of receiving nodes
- minimum time between frames 9.6 microseconds - allows recovery time for data link controllers and for the physical line to stabilize.

(2) Destination Address

- Physical address - unique address for each single node (2^{47} address possible)

- Multicast Group Address - any number of node groups can be assigned a group address. This enables all the nodes in the group to receive the same packet in a single transmission.

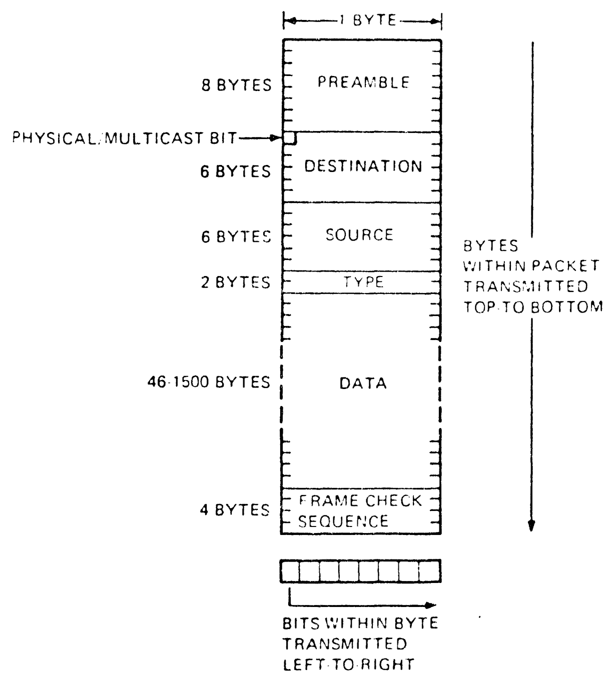
- Broadcast Address - all nodes on the Ethernet receive the packet.
- First bit in destination address field is set to indicate a physical or multicast address.

(3) Source Address - identifies the address of the sending node

(4) Type Field - specified for use by higher level protocols to allow them to identify the format of the data being sent and to determine how to process the packet (2^{16} different data formats).

(5) Data Field - data being transmitted is placed in this field (minimum size is 46 bytes, maximum size is 1,500 bytes)

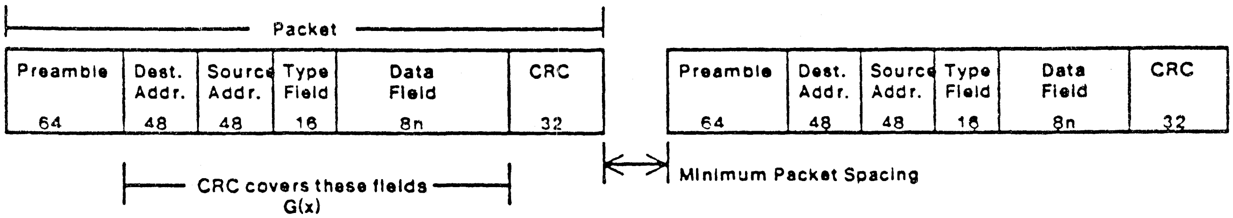
(6) Frame Check Sequence - 4 byte cycle redundancy check (CRC). This is used to check for errors in the transmitted data.



Packet Format for Ethernet

Concise Ethernet Specification

Packet Format



Stations must be able to transmit and receive packets on the common coaxial cable with the indicated packet format and spacing. Each packet should viewed as a sequence of 8-bit bytes; the least significant bit of each byte (starting with the preamble) is transmitted first.

Maximum Packet Size: 1526 bytes (8 byte preamble + 14 byte header + 1500 data bytes + 4 byte CRC)

Minimum Packet Size: 72 bytes (8 byte preamble + 14 byte header + 46 data bytes + 4 byte CRC)

Preamble: This 64-bit synchronization pattern contains alternating 1's and 0's, ending with two consecutive 1's. The preamble is: 10101010 10101010 10101010 10101010 10101010 10101010 10101010 10101011.

Destination Address: This 48-bit field specifies the station(s) to which the packet is being transmitted. Each station examines this field to determ whether it should accept the packet. The first bit transmitted indicates the type of address. If it is a 0, the field contains the unique address of the c destination station. If it is a 1, the field specifies a logical group of recipients; a special case is the broadcast (all stations) address, which is all 1

Source Address: This 48-bit field contains the unique address of the station that is transmitting the packet.

Type Field: This 16-bit field is used to identify the higher-level protocol type associated with the packet. It determines how the data field is interpret

Data Field: This field contains an integral number of bytes ranging from 46 to 1500. (The minimum ensures that valid packets will be distinguisha from collision fragments.)

Packet Check Sequence: This 32-bit field contains a redundancy check (CRC) code, defined by the generating polynomial:

$$G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

The CRC covers the address (destination/source), type, and data fields. The first transmitted bit of the destination field is the high-order term of message polynomial to be divided by G(x) producing remainder R(x). The high-order term of R(x) is the first transmitted bit of the Packet Check Sequen field. The algorithm uses a linear feedback register which is initially preset to all 1's. After the last data bit is transmitted, the contents of this regis (the remainder) are inverted and transmitted as the CRC field. After receiving a good packet, the receiver's shift register contains 11000111 000001 11011101 01111011 (x^{31}, ... ,x^{0}).

Minimum Packet Spacing: This spacing is 9.6 usec, the minimum time that must elapse after one transmission before another transmission may begin.

Round-trip Delay: The maximum end-to-end, round-trip delay for a bit is 51.2 usec.

Collision Filtering: Any received bit sequence smaller than the minimum valid packet (with minimum data field) is discarded as a collision fragment.

Control Procedure

The control procedure defines how and when a host station may transmit packets into the common cable. The key purpose is fair resolution of occasior contention among transmitting stations.

Defer: A station must not transmit into the coaxial cable when carrier is present or within the minimum packet spacing time after carrier has ende

Transmit: A station may transmit if it is not deferring. It may continue to transmit until either the end of the packet is reached or a collision detected.

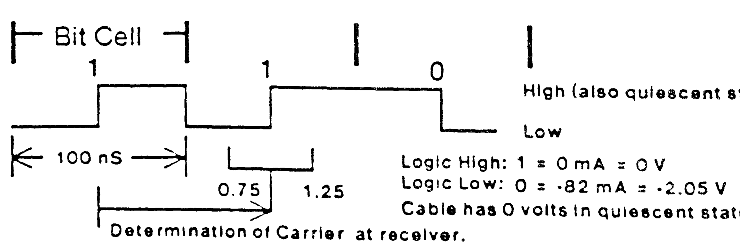
Abort: If a collision is detected, transmission of the packet must terminate, and a *jam* (4-6 bytes of arbitrary data) is transmitted to ensure that all otr participants in the collision also recognize its occurrence.

Retransmit: After a station has detected a collision and aborted, it must wait for a random *retransmission delay*, defer as usual, and then attempt retransmit the packet. The random time interval is computed using the backoff algorithm (below). After 16 transmission attempts, a higher level (e. software) decision is made to determine whether to continue or abandon the effort.

Backoff: Retransmission delays are computed using the *Truncated Binary Exponential Backoff* algorithm, with the aim of fairly resolving contention amo up to 1024 stations. The delay (the number of time units) before the n^{th} attempt is a uniformly distributed random number from [0 to 2^{n}-1] for $0<n\leq$ ($n=0$ is the original attempt). For attempts 11-15, the interval is *truncated* and remains at [0 to 1023]. The unit of time for the retransmission delay 512 bit times (51.2 usec).

Channel Encoding

Manchester encoding is used on the coaxial cable. It has a 50% duty cycle, and insures a transition in the middle of every bit cell ("data transition"). The first half of the bit cell contains the complement of the bit value, and the second half contains the true value of the bit.

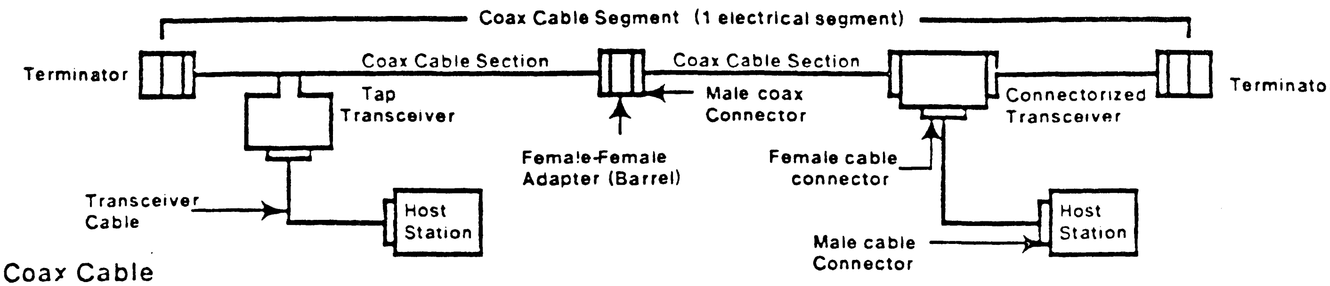


Data Rate

Data rate is 10 M bits/sec = 100 nsec bit cell ± 0.01%.

Carrier

The presence of data transitions indicates that carrier is present. If a transition is not seen between 0.75 and 1.25 bit times since the center of the la bit cell, then carrier has been lost, indicating the end of a packet. For purposes of deferring, carrier means any activity on the cable, independent being properly formed. Specifically, it is any activity on either receive or collision detect signals in the last 160 nsec.



Coax Cable

Impedance: 50 ohms ± 2 ohms (Mil Std. C17-E). This impedance variation includes batch-to-batch variations. Periodic variations in impedance of up to ± 3 ohms are permitted along a single piece of cable.

Cable Loss: The maximum loss from one end of a cable segment to the other end is 8.5 db at 10 MHz (equivalent to ~500 meters of low loss cable)

Shielding: The physical channel hardware must operate in an ambient field of 2 volts per meter from 10 KHz to 30 MHz and 5 V/meter from 30 MHz to 1 GHz. The shield has a transfer impedance of less than 1 milliohm per meter over the frequency range of 0.1 MHz to 20 MHz (exact value is a function of frequency).

Ground Connections: The coax cable shield shall not be connected to any building or AC ground along its length. If for safety reasons a ground connection of the shield is necessary, it must be in only one place.

Physical Dimensions: This specifies the dimensions of a cable which can be used with the *standard tap*. Other cables may also be used, if they are not to be used with a tap-type transceiver (such as use with connectorized transceivers, or as a section between sections to which standard taps are connected).

Center Conductor:	0.0855" diameter solid tinned copper
Core Material:	Foam polyethylene or foam teflon FEP
Core O.D.:	0.242 " minimum
Shield:	0.326" maximum shield O.D. (>90% coverage for outer braid shield)
Jacket:	PVC or teflon FEP
Jacket O.D.:	0.405"

Coax Connectors and Terminators

Coax cables must be terminated with male N-series connectors, and cable sections will be joined with female-female adapters. Connector shells shall be insulated such that the coax shield is protected from contact to building grounds. A sleeve or boot is acceptable. Cable segments should be terminated with a a female N-series connector (can be made up of a barrel connector and a male terminator) having an impedance of 50 ohms ± 1%, and able to dissipate 1 watt. The outside surface of the terminator should also be insulated.

Transceiver

CONNECTION RULES

Up to 100 transceivers may be placed on a cable segment no closer together than 2.5 meters. Following this placement rule reduces to a very low (but not zero) probability the chance that objectionable standing waves will result.

COAX CABLE INTERFACE

Input Impedance: The resistive component of the impedance must be greater then 50 Kohms. The total capacitance must be less than 4 picofarads.

Nominal Transmit Level: The important parameter is average DC level with 50% duty cycle waveform input. It must be -1.025 V (41 mA) nominal with a range of -0.9 V to -1.2 V (36 to 48 mA). The peak-to-peak AC waveform must be centered on the average DC level and its value can range from 1.4 V P-P to twice the average DC level. The voltage must never go positive on the coax. The quiescent state of the coax is logic high (0 V). Voltage measurements are made on the coax near the transceiver with the shield as reference. Positive current is current flowing out of the center conductor of the coax.

Rise and Fall Time: 25 nSec ± 5 nSec with a maximum of 1 nSec difference between rise time and fall time in a given unit. The intent is that dV/dt should not significantly exceed that present in a 10 MHz sine wave of same peak-to-peak amplitude.

Signal Symmetry: Asymmetry on output should not exceed 2 nSec for a 50-50 square wave input to either transmit or receive section of transceiver.

TRANSCEIVER CABLE INTERFACE

Signal Pairs: Both transceiver and host station shall drive and present at the receiving end a 78 ohm balanced load. The differential signal voltage shall be 0.7 volts nominal peak with a common mode voltage between 0 and +5 volts using power return as reference. (This amounts to shifted ECL levels operating between Gnd and +5 volts. A 10116 with suitable pulldown resistor may be used). The quiescent state of a line corresponds to logic high, which occurs when the + line is more positive than the - line of a pair.

Collision Signal: The active state of this line is a 10 MHz waveform and its quiescent state is logic high. It is active if the transceiver is transmitting and another transmission is detected, or if two or more other stations are transmitting, independent of the state of the local transmit signal.

Power: +11.4 volts to +16 volts DC at controller. Maximum current available to transceiver is 0.5 ampere. Actual voltage at transceiver is determined by the interface cable resistance (max 4 ohms loop resistance) and current drain.

ISOLATION

The impedance between the coax connection and the transceiver cable connection must exceed 250 Kohms at 60 Hz and withstand 250 VRMS at 60 Hz.

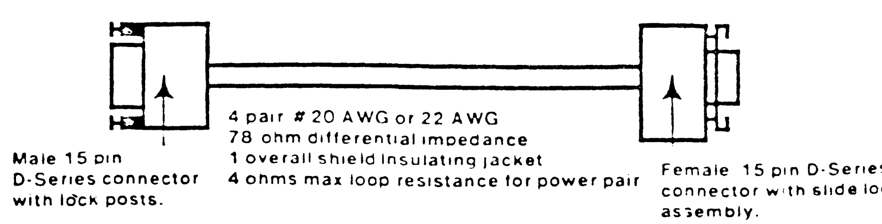
Transceiver Cable and Connectors

Maximum signal loss = 3 db @ 10 MHz. (equivalent to ~50 meters of either 20 or 22 AWG twisted pair).

Transceiver Cable Connector Pin Assignment

1.	Shield*		
2	Collision +	9.	Collision -
3	Transmit +	10	Transmit -
4	Reserved	11	Reserved
5	Receive +	12.	Receive -
6	Power Return	13.	+ Power
7.	Reserved	14	Reserved
8	Reserved	15.	Reserved

*Shield must be terminated to connector shell.



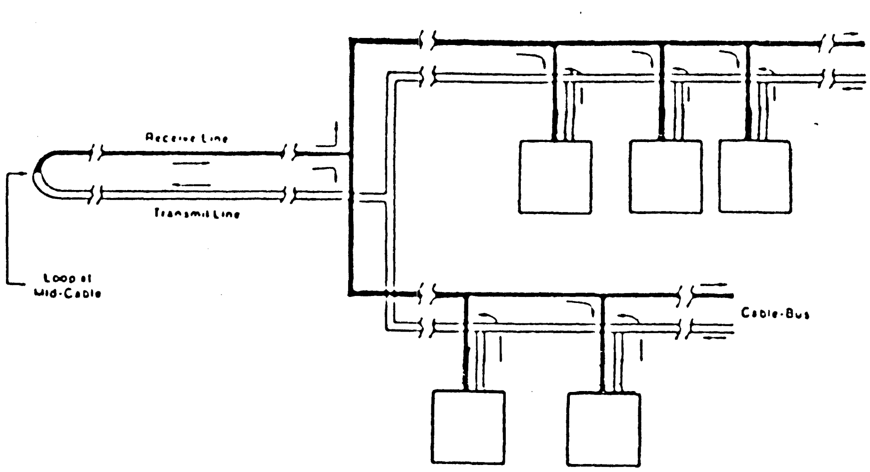
2. <u>Broadband</u> <u>Approach</u>

- <u>Broadband</u> is a term that describes a type of wide band communications network that uses coaxial cable as its distribution medium and frequency division multiplexing as its channel allocation scheme.

  A. Physical Layer

  Topology: branching tree

  - <u>Headend</u> represents the base of the tree
  - <u>Distribution</u> <u>Network</u> represents the branches of the tree
  - <u>Dual</u> <u>Cable</u> <u>(end-split)</u> <u>Broadband</u> <u>Bus</u> - two cables are connected with a loop at mid cable



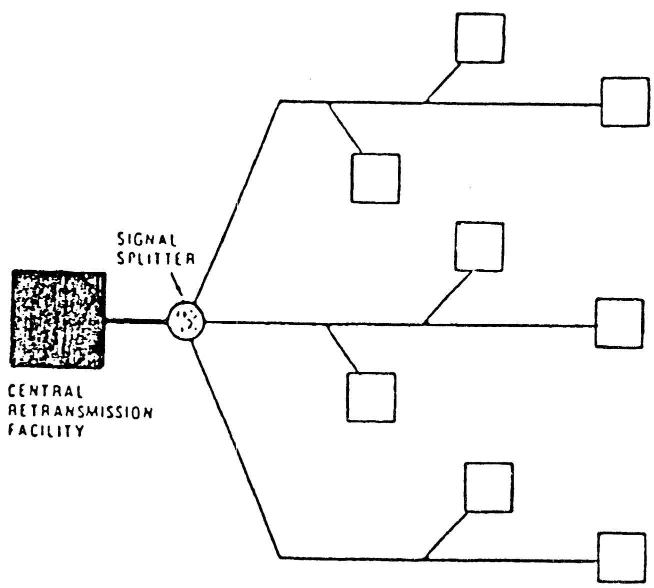
Dual Cable (End-Split) Broadband Bus

Frequency Range	Description	Typical Hardware
10-15 MHz	48 FDX, dedicated, point-point channels, each set at fixed frequency, to support data rates of up to 9.6K bps	1 fixed-frequency modem per user device conforming to RS232-C
15-25 MHz	32 FDX, dedicated, point-point channels, each set at fixed frequency, to support data rates of up to 64K bps	1 fixed-frequency modem per user device conforming to RS449
25-55 MHz	Unused/Reserved	
55-75 MHz	128 FDX, switched point-point channels, to support data rates of up to 9.6K bps	1 variable-frequency modem per user device conforming to RS232-C PLUS 1 data switch for the 128 channels
75-175 MHz	Unused/Reserved	
175-210 MHz	CSMA/CD controlled channel for data transmission at rates of approximately 10M bps	1 CIU per user device containing CSMA/CD logic PLUS very high-speed modem
210-240 MHz	5 standard CATV video channels (6 MHz each)	Customized and/or standard (CATV) video equipment transmission
240-310 MHz	Unused/Reserved	

Sample Frequency Allocation Scheme for a
Dual-Cable, 300 MHz Broadband LAN

- Single Cable (mid-split) Broadband Bus - single cable is divided into two frequency bands (FDM). Normally the higher frequency band is for transmitting (outbound or forward path). Normally the lower frequency band is for receiving (inbound or return path).

  - Central Retransmission Facility (CRF) - a device that consists of amplifier, filters, and signal modulators. Its purpose is to shift all frequency in the transmit band to the receive band. It is only required for single cable broadband bus.



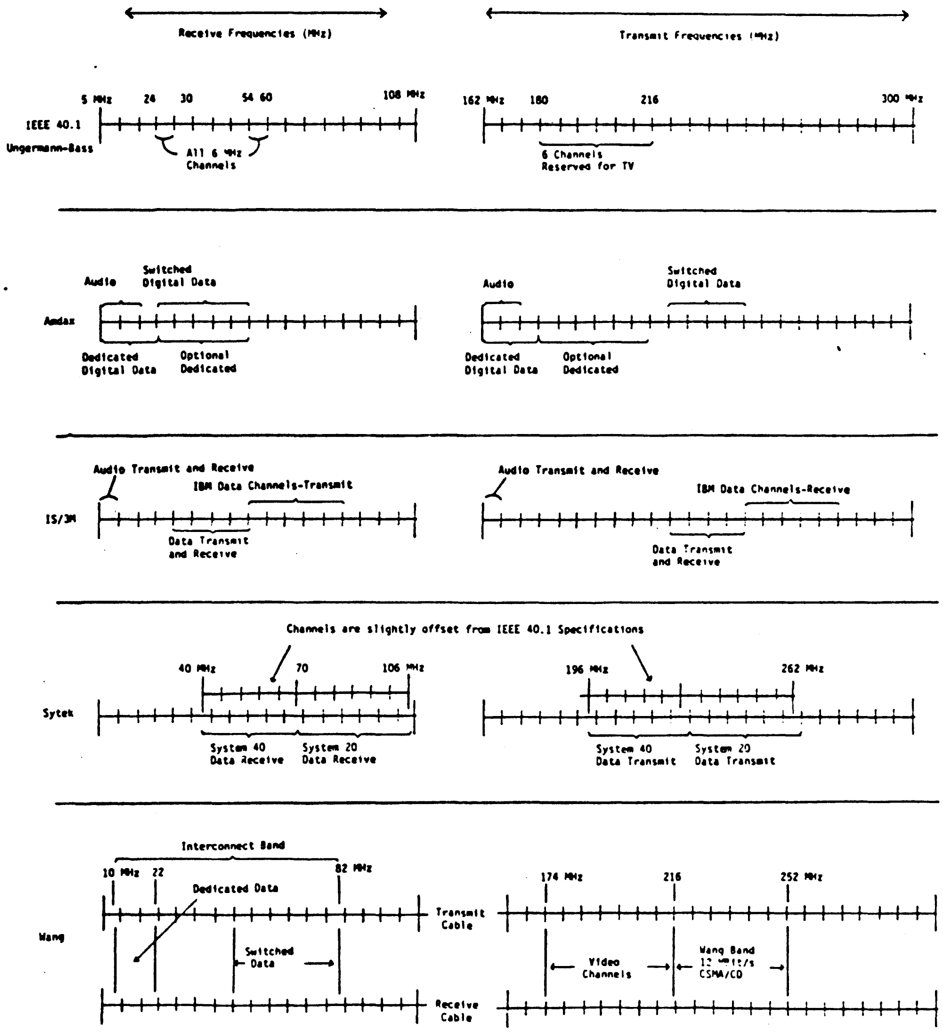
Single Cable (Mid-Split) Broadband Bus

Medium: 75 ohm CATV coaxial cable

Signaling: may be mixture of voice, video and data. Data transmission is via Radio Frequency (RF) modem. The transmitting and receiving frequencies may be fixed or adjustable (switched).

Data Rate: up to 10M bps (9.6K bps, 64K bps, 10M bps).

Sample Frequency Allocations for Single Cable (mid-split) Broadband Bus



note: Wang uses a 2-cable configuration; one for transmission, the other for reception.

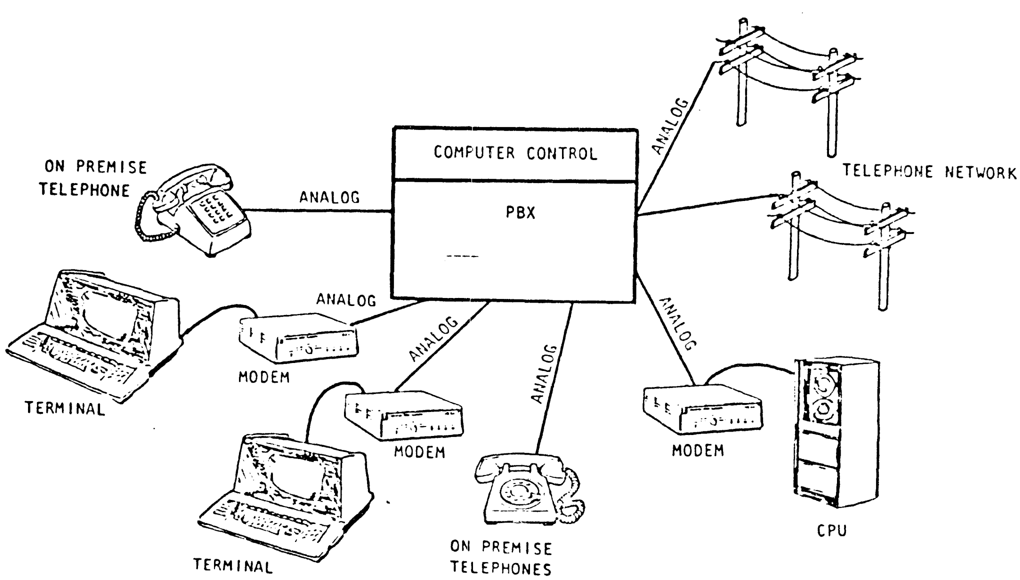
3. Private Branch Exchange (PBX) and Private Automatic Branch Exchange (PABX) Approach

- A system that permits connecting of calls between parties on the same premises, and switching calls between the premises and the outside telephone network.
- Topology: star
- Medium: twisted pair
- Signaling: carrier modulation

A. Types of PBX's

<u>PBX</u> - switches analog signals electro-mechanically

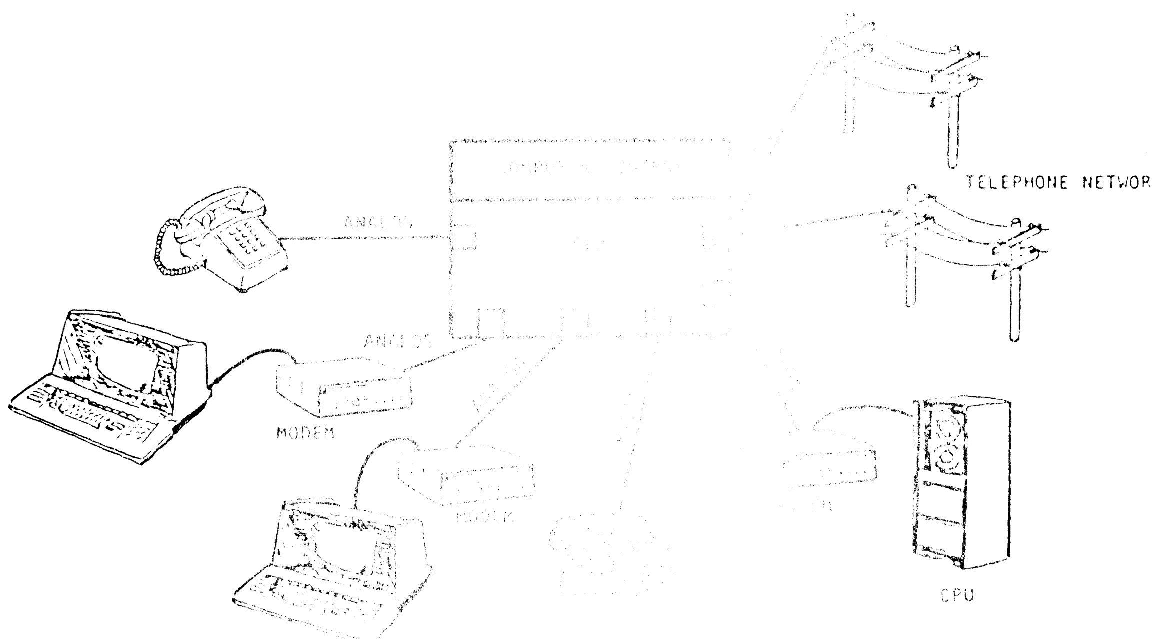
- Internal and external telephone voice conversations (analog) enter the switch directly, and are connected to other Telephones within the premises. Internal calls can be switched to the external telephone network.
- Computer signals are converted to analog form by modems and are switched to computers, terminals, or other data devices in which the signal is converted back to digital form.
- Terminals are connected to the switch via modems (which make the D/A conversion) that are connected to a telephone. The telephone is used to dial up a port on the switch and the switch connects the terminal to computers, other terminals, or other data devices, again with the conversion back to digital made at the receiving end.
- Data rates up to 9.6K bps



Private Branch Exchange (PBX)

Computerized Branch Exchange (CBX)

- Computer controlled switch that uses time division multiplexing (TDM) to allocate and switch available channels. All input to switch are analog.
- Analog signals are converted to digital signals with [illegible] decoder) at the CBX.
- Digital signals [illegible] are converted to analog signals [illegible]
- Date rates up to [illegible]



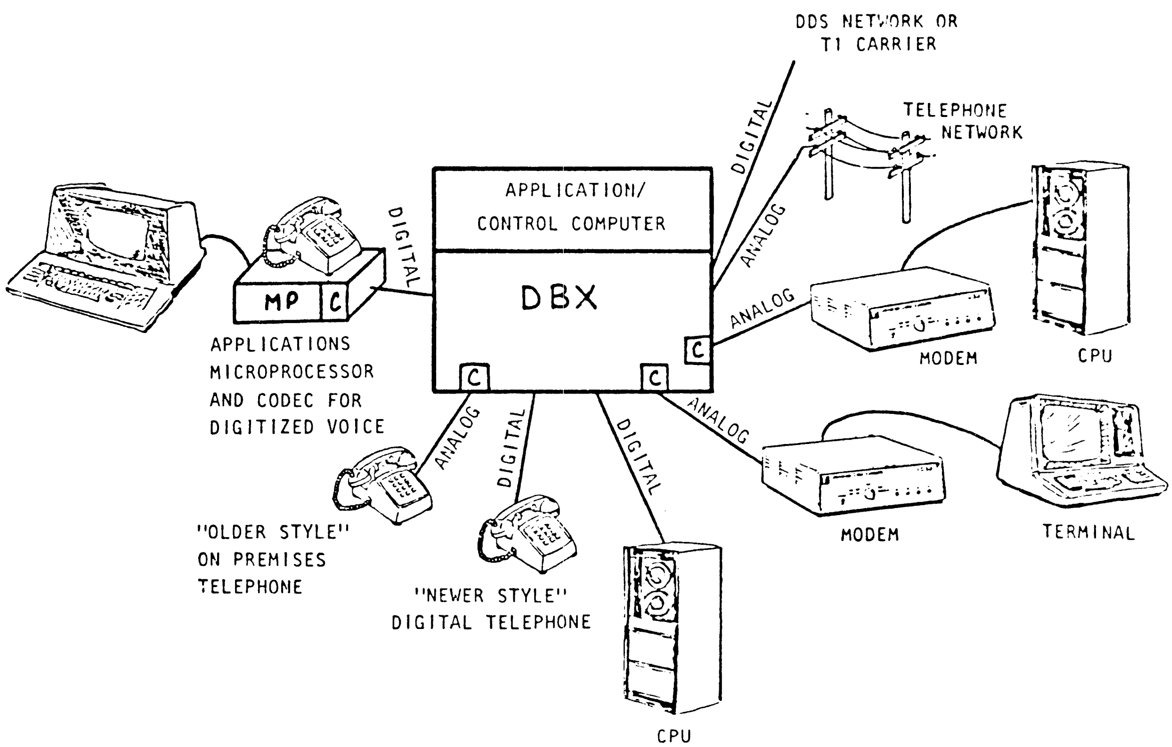
Computerized Branch Exchange (CBX)

Digital Branch Exchanges (DBX)

- Computer control switch that use Time Division Multiplexing (TDM) to allocate and switch available channels. Inputs to switch may be analog or digital.

- CODEC's are used to convert analog signals to digital and digital signals to analog for analog inputs.

- Data rates: Analog up to 9.6K bps
  Digital up to 56K bps



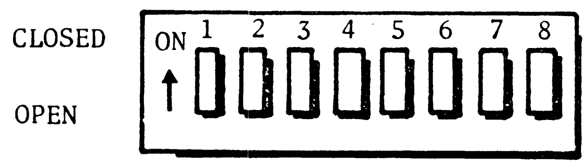
Digital Branch Exchange (DBX)

In the future, it is possible for a nationwide and worldwide digital telecommunications network. Standards are now being created for this network. This network is call the Intergrated Services Digital Network or Intergrated Switched Digital Network (ISDN).

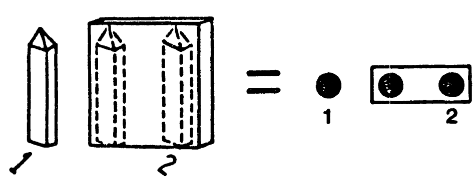
IX. Modem Switch, Strap, and Soft Option

Most modems have user options that may be selected. These options permit the user to reconfigure the modem for his particular application.

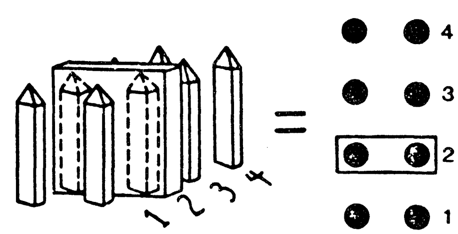
<u>Switch Options</u> - user selects options with a DIP (Dual Inline Package) switch.



<u>Strap Options</u> - user selects options by moving short bar between different sets of pins.

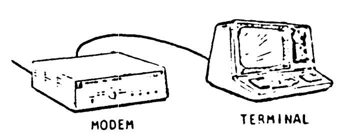


Strapped to position 2



Strapped to position 2

<u>Soft Switch Option</u> - user selects options by typing commands to the modem through the terminal equipment.



Example:

Command	Option
OBO	Pulse Dialing
OB1	DTMF Dialing
OB2	Auto Select DTMF or Pulse Dialing

208 A/B OPTION DESCRIPTION

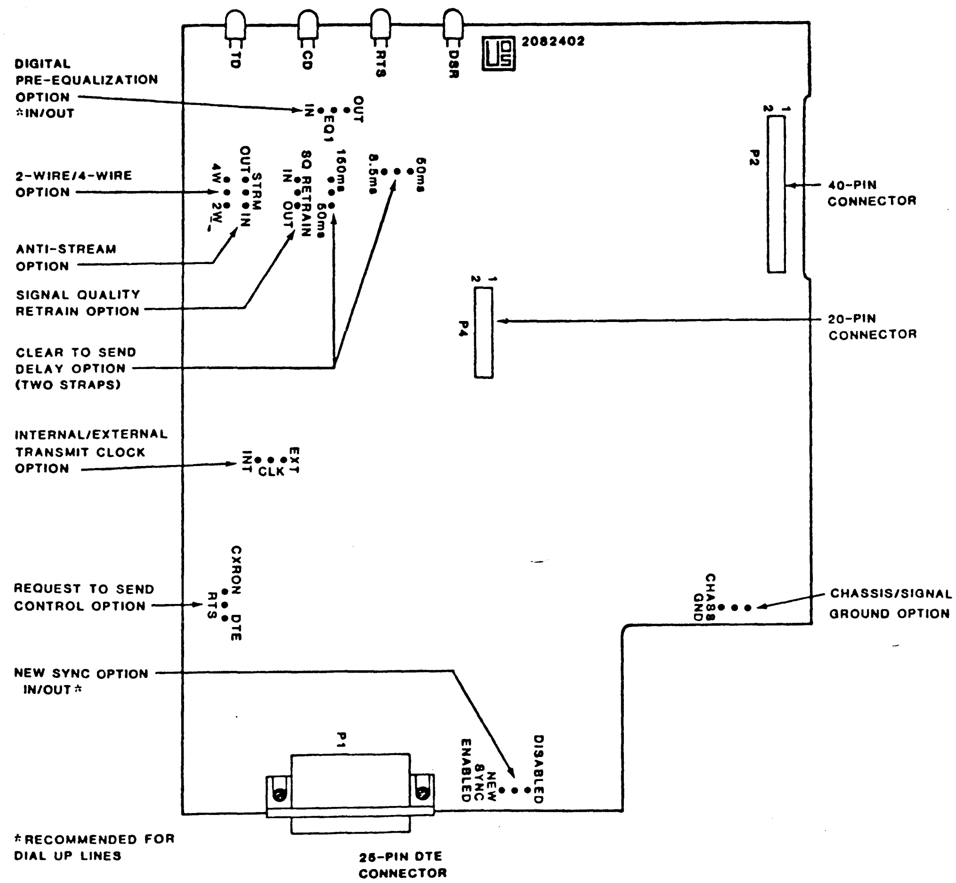
FEATURE	STRAP LOCATION	STRAP DESIGNATION	208A 4-WIRE PRIVATE LINE	208A 2-WIRE PRIVATE LINE	208B 2-WIRE DIAL UP	FUNCTION
Request to Send Control	Top Board	RTS DTE/CXR ON	DTE RTS / O CXR ON (F)	DTE RTS / O CXR ON (F)	DTE RTS / O CXR ON (F)	RTS Controlled By The Terminal.
			O DTE RTS / CXR ON	O DTE RTS / CXR ON	O DTE RTS / CXR ON	Constant Carrier Output
Internal or External Transmit Clock	Top Board	(Customer Option) EXT/INT CLK	INT / O EXT (F)	INT / O EXT (F)	INT / O EXT (F)	Transmit Clock Supplied By Modem No External Clock Supplied
			O INT / EXT	O INT / EXT	O INT / EXT	External Transmit Clock Supplied By Terminal.
Digital Pre-Equalization	Top Board	(Customer Option) EQL IN/OUT	OUT O / EQL / IN (F)	OUT O / EQL / IN (F)	OUT O / EQL / IN (F)	Enabled (Digital Pre-Equalization should be enabled for all normal operation.)
			OUT / EQL / IN O	OUT / EQL / IN O	OUT / EQL / IN O	Disabled
Clear to Send	Top Board	CTS Delay 8.5 ms/50 ms (Master Unit Only) CTS Delay 150 ms/50 ms	8.5 ms / CTS / 50 ms O 50 ms / CTS / 150 ms O			8.5 ms Clear To Send (Two straps are required.) For Central Site Polling Application.
		CTS Delay 8.5 ms/50 ms (Customer Option) CTS Delay 150 ms/50 ms	8.5 ms O / CTS / 50 ms 50 ms O / CTS / 150 ms	8.5 ms O / CTS / 50 ms 50 ms O / CTS / 150 ms	8.5 ms O / CTS / 50 ms 50 ms O / CTS / 150 ms (F)	150 ms Clear To Send (Two straps are
		CTS Delay 8.5 ms/50 ms (Customer Option) CTS Delay 150 ms/50 ms	8.5 ms O / CTS / 50 ms 50 ms / CTS / 150 ms O (F)	8.5 ms O / CTS / 50 ms 50 ms / CTS / 150 ms O (F)	8.5 ms O / CTS / 50 ms 50 ms / CTS / 150 ms O	50 ms Clear To Send (Two straps are required.)
Signal Quality Retrain	Top Board	SQ Ret OUT/IN (Customer Option)	O OUT / SQ RET / IN (F)	O OUT / SQ RET / IN (F)	O OUT / SQ RET / IN (F)	Enabled
			OUT / SQ RET / O IN	OUT / SQ RET / O IN	OUT / SQ RET / O IN	Disabled
New-Sync	Top Board	New-Sync OUT/IN (Customer Option)	O IN / NS / OUT (F)	O IN / NS / OUT (F)	O IN / NS / OUT (F)	New-Sync Disabled
			IN / NS / O OUT	IN / NS / O OUT	IN / NS / O OUT	New-Sync Enabled
2-Wire/4-Wire Option	Top Board	2-Wire/4-Wire	4W / 2W O (F)			4-Wire
				4W O / 2W (F)	4W O / 2W (F)	2-Wire
Anti-Stream	Top Board	STRM (Spare) IN/OUT	O IN / OUT (F)	O IN / OUT (F)	O IN / OUT (F)	Disabled
			IN / O OUT	IN / O OUT	IN / O OUT	Enabled - For Remote Site Polling Applications.
Dial Thru Enable	Top Board	Dial Thru Enable DIS/EN	DIS / O EN	DIS / O EN	DIS / O EN (F)	Disabled - Dial Thru Not Used
					O DIS / EN	Enabled - Dial Thru Used

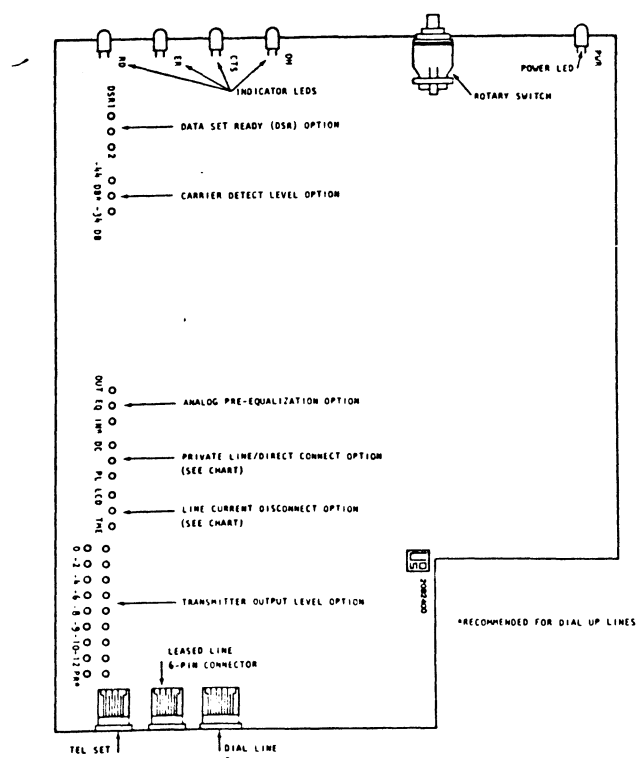
(F) TYPICAL FACTORY STRAPPING UNLESS OTHERWISE SPECIFIED.

208 A/B OPTION DESCRIPTION (cont.)

FEATURE	STRAP LOCATION	STRAP DESIGNATION	208A 4-WIRE PRIVATE LINE	208A 2-WIRE PRIVATE LINE	208B 2-WIRE DIAL UP	FUNCTION
Chassis/ Signal Ground Option	Top Board	Signal Ground Chassis Ground (Customer Option)	SG CG O	SG CG O	SG CG O	Signal Ground Not Connected To Chassis Ground
			O SG F CG	O SG F CG	O SG F CG	Signal Ground Connected To Chassis Ground
DSR Option	Bottom Board	OFF/ON (Customer Option)	1 O 2	1 O 2		DSR ON In Loop-back NOTE: DSR ON Indicates Modem Is Off Hook In Dial-up Mode.
			O 1 F 2	O 1 F 2		DSR OFF In Loopback
Carrier Detect Level	Bottom Board	RLSD Threshold	-44 RLSD -34dBm O	-44 RLSD -34dBm O	-44 RLSD -34dBmO F	-44 dBm Level
			-44 O RLSD F -34dBm	-44 O RLSD F -34dBm	-44 O RLSD -34dBm	-34 dBm Level
Analog Pre-Equalization	Bottom Board	Analog Pre-Equalization (Customer Option)	OUT O F IN	OUT O F IN	OUT O F IN	Unconditioned Lines (3002)
			OUT IN O	OUT IN O	OUT IN O	Conditioned Lines (C 2)
Private Line/ Direct Connect	Bottom Board	Direct Connect Private Line Line Current Disconnect Time	O DC PL F O LCD TIME	O DC PL F O LCD TIME		Private Line
Line Current Disconnect		Direct Connect Private Line Line Current Disconnect Time			O DC PL LCD O TIME	Direct Connect No Line Current Disconnect
		Direct Connect Private Line Line Current Disconnect Time			DC O PL F O LCD TIME	Direct Connect 8 ms Line Current Disconnect (Recommended for most dial applications.)
		Direct Connect Private Line Line Current Disconnect Time			DC O PL LCD O TIME	Direct Connect 90 ms Line Current Disconnect
Transmit Output Level	Bottom Board	0 dBm -2 -4 -6 -8 -9 -10 -12 PR	0 dBm O O -2 O O -4 O O -6 O O -8 F O O -9 O O -10 O O -12 O O PR	0 dBm O O -2 O O -4 O O -6 O O -8 F O O -9 O O -10 O O -12 O O PR	* O O 0 dBm O O -2 O O -4 O O -6 O O -8 F -9 RJ11C O O -10 O O -12 O O PR	The PR Position Provides -12 dBm OUTPUT LEVEL In Private Line Operation And Dial-up Operation Where No External Programming Resistor (RJ11C Jack) Is Provided.

* -9 PERMISSIVE MODE PART 68 AND USE RJ11C JACK.
FOR PROGRAMMABLE MODE PART 68 STRAP "PR" AND USE RJ45S JACK.





NOTE: THE PR POSITION PROVIDES -12dBm OUTPUT LEVEL IN PRIVATE LINE OPERATION AND DIAL UP OPERATION WHERE NO EXTERNAL PROGRAMMING RESISTOR (RJ11C JACK) IS PROVIDED.

TYPICAL STRAP OPTION MAP

X. Data Communication Link Testing

1. Transmission Impairment Measurement Set

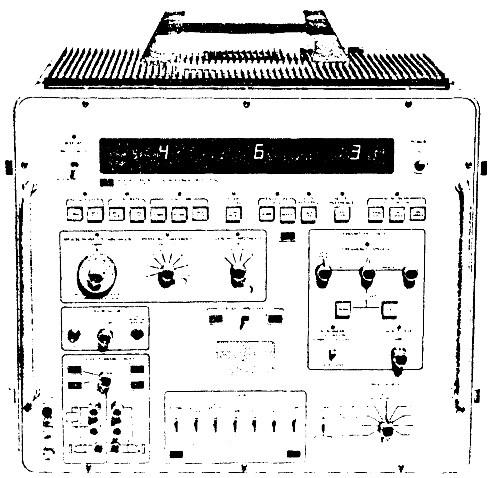
548

TELECOMMUNICATIONS TEST EQUIPMENT

Transmission Impairment Measuring Sets (TIMS)

Models 4940A

- Complete analog testing of voice/data channels
- Compatible with North American Standard
- Low frequency phase jitter



4940A

TIMS—Transmission Impairment Measuring Set

Most of the important analog parameters can be measured by a combined assortment of analog test sets which measure only a few parameters. However, TIMS are "stand alone" combination test sets that measure 7 to 15 parameters depending on the model and options selected. Thus TIMS can replace a large number of analog test sets. The major advantages of TIMS are that they cost significantly less and are more compact and more portable than a combination of test sets required to do the same measurements.

In addition to cost savings and portability, TIMS are easy to operate. The switches on the front panel are logically arranged in functional groups. Simple straight-forward operating procedures allow the craftsperson or engineer to quickly and easily analyze voice band data channel.

4940A TIMS—Complete Analog Testing

The HP 4940A measures all the necessary parameters to completely describe the ability of a voiceband channel to carry medium and high speed data. The 4940A is the ideal tool for analyzing and troubleshooting C and D-1 conditioned lines.

With the HP 4940A it is possible simultaneously to observe all of the transients that cause data errors. By counting phase hits, gain hits, dropouts and three levels of impulse noise at the same time, a more accurate analysis can be made of error causes and channel quality. All of these transients are totalled by TIMS during the selected count time and stored in memory. The pushbutton-selectable count times are 5, 15 minutes and continuous. During the test and at the end of the count time, either the impulse noise totals or the hits and dropout totals may be displayed from memory.

The 4940A TIMS measures the peak-to-peak phase jitter in two separate bands. Bell standard phase jitter is measured in the frequency band of 20 Hz to 300 Hz, and Bell low frequency phase jitter is measured in the frequency band of 4 Hz to 20 Hz. By measuring the peak-to-peak phase jitter in each band, you can identify positively the existence of low frequency phase jitter from standard phase jitter.

4940A Specifications

For detailed specifications ask your local HP sales office for a 4940A TIMS data brochure.

General

Power: 105 to 129 V AC, 60 Hz, 130 watts.
Dimensions: 464 H x 470 W x 32.4 mm D (18.3" x 18.5" x 12.8")
Weight: net, 18 kg (39 lb). Shipping, 25 kg (54 lb).

Options

001: adds P/AR measurement
002: adds nonlinear distortion measurement
003: adds P/AR and nonlinear distortion measurements
004: adds P/AR, nonlinear distortion and low frequency phase jitter
010: Field carrying case
019: 19" Rack Mount Adapter, deletes cover
023: 23" Rack Mount Adapter, deletes cover
910: extra set of manuals

The nonlinear distortion technique is licensed under Hekimian Laboratories, Inc., USA Patent No. 3862380.

4940A Transmission Impairment Measuring Set

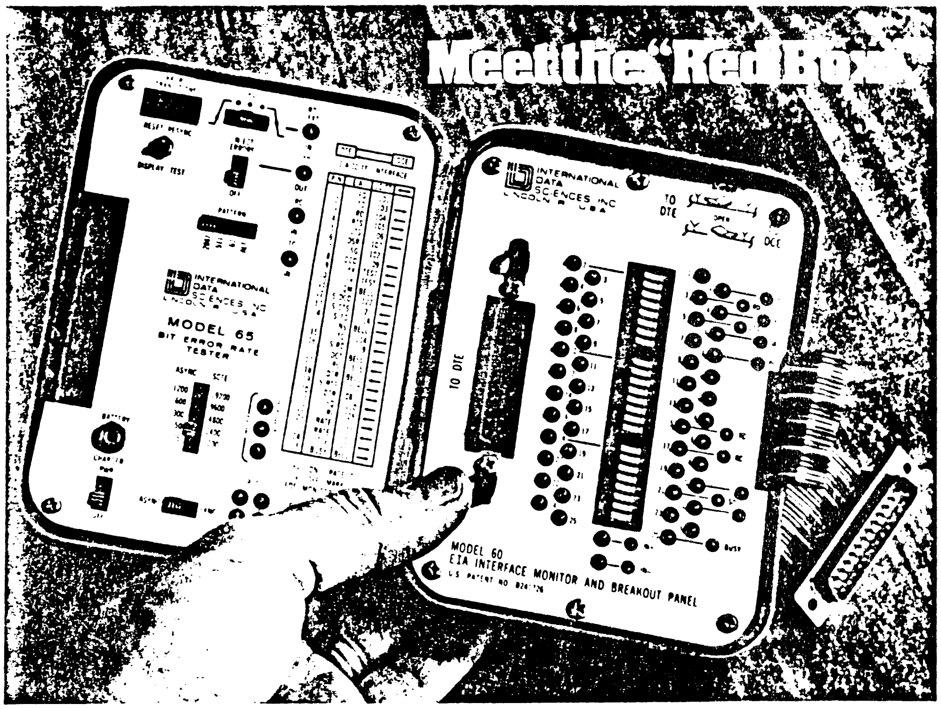
Measures level and frequency, message circuit noise (C-message and 3 kHz flat), noise-with-tone, 3-level impulse noise, phase hits, gain hits, dropouts, phase jitter, envelope delay, noise-to-ground.

Low frequency phase jitter can be retrofit at an HP Service Center.

4940A, 4943A and 4944A Comparison

Measurement	4940A	4943A	4944A
Message Circuit Noise-C-Message	•	•	•
3 kHz Flat	•	•	•
Noise with Tone	•	•	•
Attenuation Distortion	•	•	•
Envelope Delay Distortion	•	•	•
Impulse Noise 1 Level	•	•	•
3 Levels	•		
Phase Hits	•		
Gain Hits	•		
Dropouts	•		
Phase Jitter	•	•	
Low Frequency Phase Jitter	•†	•†	
Non-Linear Distortion	•†		•
Peak to Average Ratio	•†		
Noise to Ground	•		
Signal to Noise Ratio		•	•
† Options			

2. Break Out Box



Model 65/60

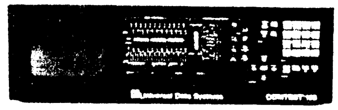
Bit Error Rate Tester and EIA Breakout Panel

The Model 65/60 is composed of two separate units packaged in a lightweight, pocket-size carrying case. Model 65 is a complete miniaturized modem test set capable of performing bit error rate tests on synchronous and asynchronous EIA data communications channels. The Model 60 is our popular "Blue Box" EIA Monitor and Breakout Panel described previously. Together, they provide for the first time, a hand-held, battery-powered unit for testing and monitoring data communications systems at the EIA RS-232/CCITT V.24 modem-terminal interface.

The Model 65 is a completely self-contained test set capable of analyzing the bit error rate of digital data communication channels. It contains separate transmitter and receiver sections, allowing full-duplex tests to be performed in either end-to-end or loopback configurations. The transmitter continuously generates one of four switch selectable data patterns which include 63-, 511-, and 2047-bit repeating pseudo-random sequences; and an alternating mark-space pattern. Steady all-mark or all-space signals may also be transmitted to detect mark-to-space or space-to-mark transitions, respectively. The receiver section generates a true replica of the selected transmitted data pattern and compares this error-free replica with the received data pattern. A bit-by-bit comparison is then performed, with detected bit errors counted and displayed on a three digit LED readout. An overflow is indicated whenever the count exceeds 999. If the receiver loses synchronization with the received data pattern, the LED display will indicate an overflow. Resynchronization is accomplished at the touch of a button.

Power for the Model 65/60 is supplied by two 9-volt rechargeable Ni-Cad batteries and an AC adaptor/charger is provided for 115 VAC, 60 Hz or 230 VAC 50 Hz operation using the Model 22 or 23, respectively. Dimensions are: 3¾"W x 5"H x 1¾"D (9.52 cm W x 12.7 cm H x 4.45 cm D) and the unit weighs 1 pound (batteries included).

3. Data Line Monitor



COMTEST 100

The Comtest 100 is a passive, non-interactive data analyzer that permits the operator to observe network traffic without interrupting normal communications. It is specifically user-oriented to provide an extremely comprehensive repertory of digital data monitoring technology. Comtest 100 units have an integral 5-inch CRT and can be either stand-alone or rack-mounted. A composite video output may drive an external CRT. The unit also includes an integral "patch panel" capability.

Data storage capabilities may be extended and made non-volatile with the addition of the optional disk storage units.

MODE
Monitor Both, Monitor Send, Monitor Receive, Hunt Send, Hunt Receive, Find Clock Rate, Find Data Less Than Or Equal To 300 Bits/Sec, Find Data Greater Than 300 Bits/Sec

LINE TYPE
Asynchronous, Synchronous, Isochronous, Binary Synchronous (with block check), IPARS (with block check), SDLC (with frame checking)

LANGUAGE
ASCII, EBCDIC, Baudot, XS-3, EBCD, Correspondence, IPARS

BITS/CHARACTER
5, 6, 7, 8 (not counting parity)

PARITY
Even, Odd, or None

DATA SENSE
Normal (STD, RS-232C), Inverting, (MIL. 188 and airlines), NRZI (some SDLC installations)

BIT RATES
50 to 9600bps full duplex, 50 to 19,200bps half duplex. Selectable: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200. Dissimilar transmit and receive rates are supported.

DATA STORAGE
3500 characters, recallable on command and fully identified with error, intermessage time statistics, triggers and traps. Full forward and reverse scroll during recall.

DISK STORAGE
1.75 million bits (unformatted) per disk surface. 89,600 formatted and annotated bytes per surface. Up to 358,400 bytes on 4 surfaces.

DISK OPERATIONS
Erase and initialize. Record on line, Record from data buffer, Replay to video display, Replay to data buffer.

OPTIONS
SDLC, Binary Synchronous Communications (BSC) Special bit-rate, IPARS, Special default parameters, Carrying Case, One or more disk units.

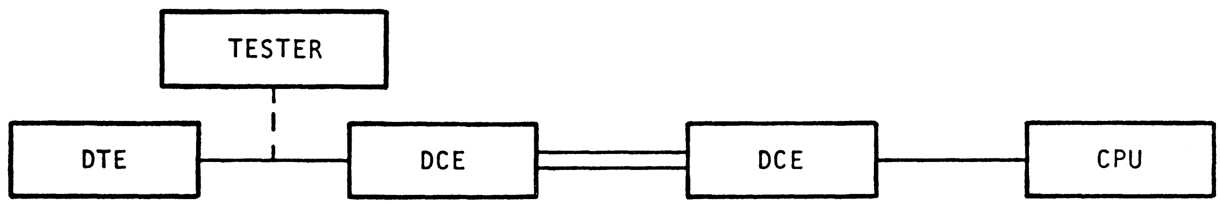
DIMENSIONS
5.2 x 16.0 x 12.5 in.

WEIGHT 17.4 lbs.

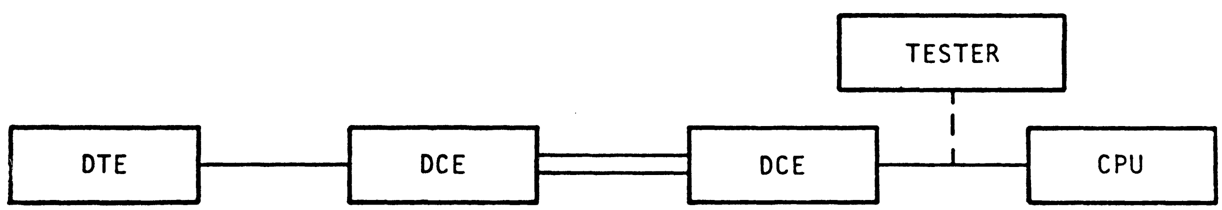
LINE POWER
120 or 240 Vac (switch selectable), 47 to 63 Hz

ENVIRONMENT
Operating Temperature: 5° C to 50° C;
Operating Humidity — Up to 90 percent non-condensing

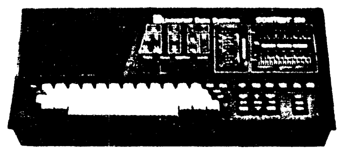
MONITOR MODE



MONITOR MODE



4. Data Line Emulator



COMTEST 200

The Comtest 200 is a versatile, user-oriented data communications analyzer. It provides an extremely comprehensive repertory of digital data monitoring, emulation, and recording technology. An integral "patch panel" provides flexibility in accessing the RS-232C interface. Data presentation and operator control are accomplished through the integral 5-inch CRT and full keyboard. User programmable emulation functions provide the capability to interactively test virtually any network configuration. Data storage capabilities may be extended and made non-volatile with the addition of the optional disk storage unit.

MODE
Conventional: Monitor Both, Monitor Send, Monitor Receive, Local Emulate, Remote Emulate, Hunt Send, Hunt Receive, and Test. Find: (five functions). Special (BERT): Four 511 Pattern Functions

LINE TYPE
Asynchronous, Synchronous, Isochronous, Binary Synchronous (with block check), IPARS (with block check), SDLC (with frame checking), DDCMP, Frame and X.25 Packet Disassembly.

LANGUAGE
ASCII, EBCDIC, Baudot, XS-3, EBCD, Correspondence, IPARS, Transcode, BCD

BITS/CHARACTER 5, 6, 7, 8 (not counting parity)

PARITY Even, Odd, or None

DATA SENSE
Normal (STD, RS-232C), Inverted (MIL. 188 and airlines), NRZI (some SDLC installations)

BIT RATES
50 to 9600bps full duplex. 50 to 19,200bps half duplex. Selectable: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200. Dissimilar transmit and receive rates are supported.

DATA STORAGE
4000 characters, recallable on command and fully identified with error, intermessage time statistics, triggers and traps. Full forward and reverse scroll during recall. Paging, usage reporting and buffer clear functions are provided.

DISK STORAGE
1.75 million bits (unformatted) per disk surface. 89,600 formatted and annotated bytes per surface. Up to 358,400 bytes on 4 surfaces.

DISK OPERATIONS
Erase and Initilize, Record on line, Record from Data Buffer, Replay to video display, Replay to Data Buffer, Copy Disk to Disk, Store user programs.

OPTIONS
Special bit-rate, Special default parameters, Carrying Case, One or more disk units.

DIMENSIONS 7.0 x 18.7 x 16.5 in.

WEIGHT 23.9 lbs.

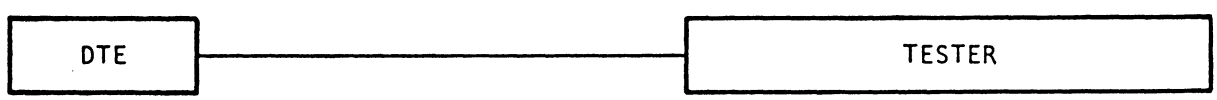
LINE POWER
120 or 240 Vac (switch selectable), 47 to 63 Hz

ENVIRONMENT
Operating Temperature: 5°C to 50°C;
Operating Humidity — up to 90 percent non-condensing

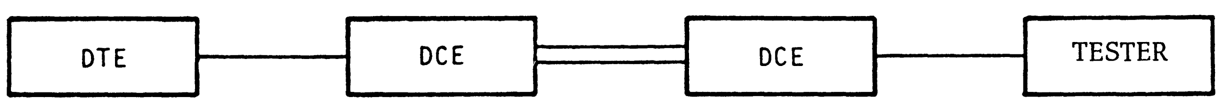
LOCAL EMULATION

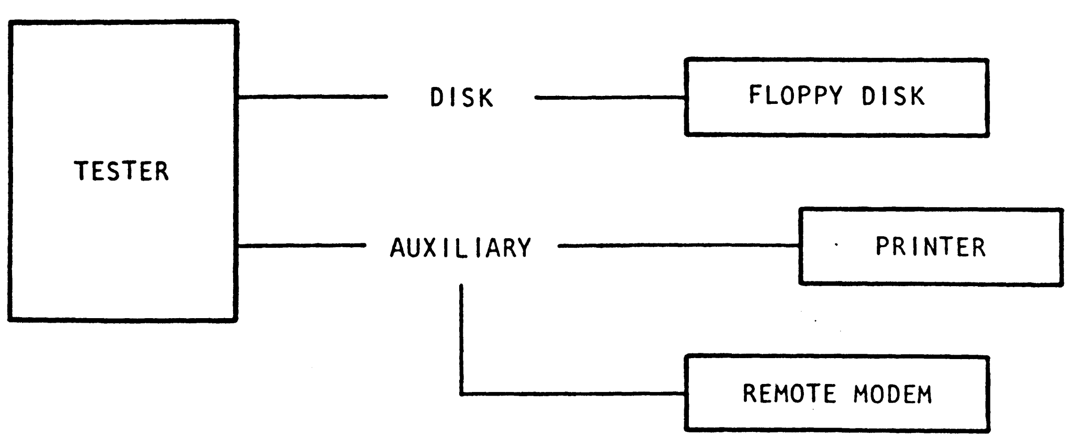
REMOTE EMULATION

REMOTE EMULATION



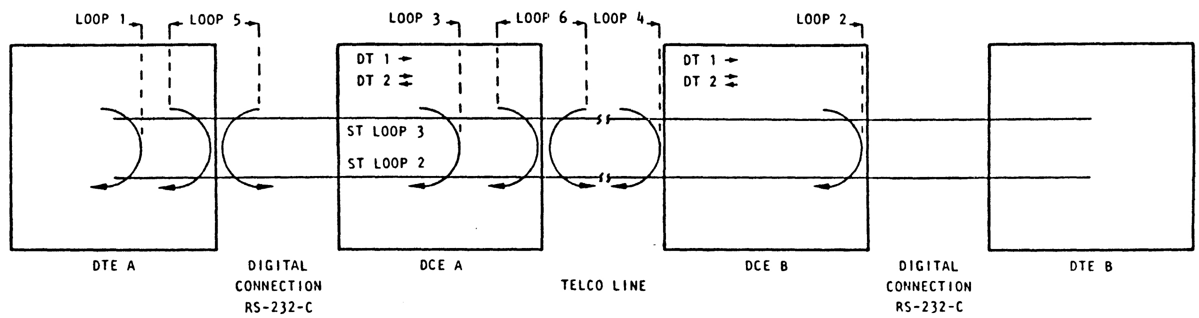
LOCAL EMULATION



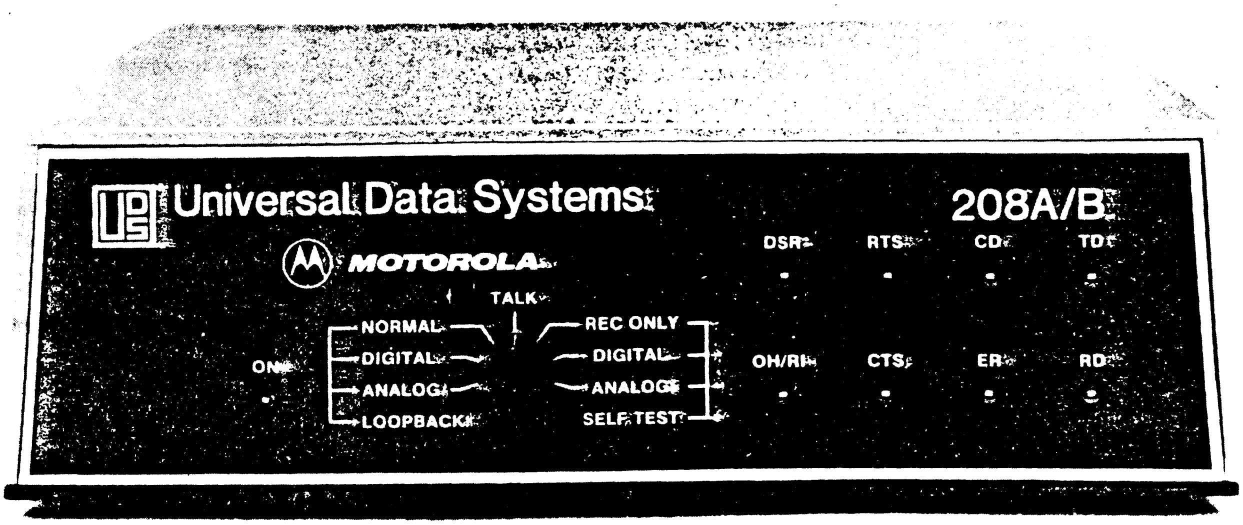


Options for Data Line Monitoring or Emulation Equipment

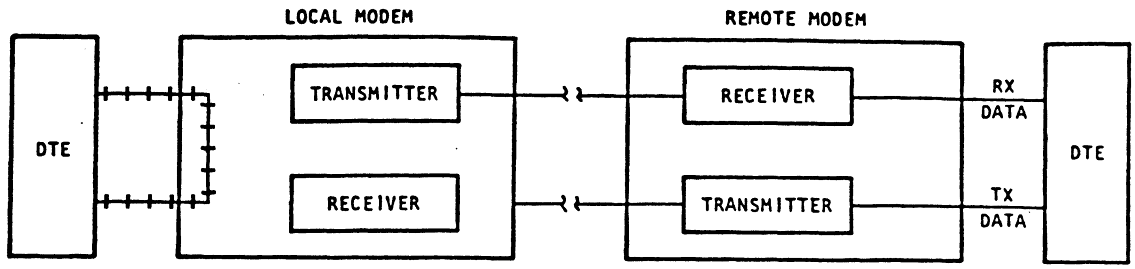
5. Built in Modem Tests



TEST NAME	DESCRIPTION
LOOP 1	DIGITAL LOOPBACK TO DTE A
LOOP 2	DIGITAL LOOPBACK THROUGH DCE B TO DCE A
LOOP 3	ANALOG LOOPBACK TO DTE A
LOOP 4	ANALOG LOOPBACK THROUGH DCE B TO DTE A
LOOP 5	DIGITAL LOOPBACK PROVIDED TO BOTH DTE A AND DCE A
LOOP 6	ANALOG LOOPBACK TO BOTH DCE A AND DCE B
ST LOOP 3	ANALOG LOOPBACK WITH SELF TEST FUNCTION ACTIVATED
ST LOOP 2	DIGITAL LOOPBACK WITH SELF TEST FUNCTION ACTIVATED
DT 1 ←	TRANSMIT ONLY TEST (DCE A) TO RECEIVE ONLY TEST (DCE B)
DT 2 ⇄	END TO END TEST BETWEEN DCE A AND DCE B

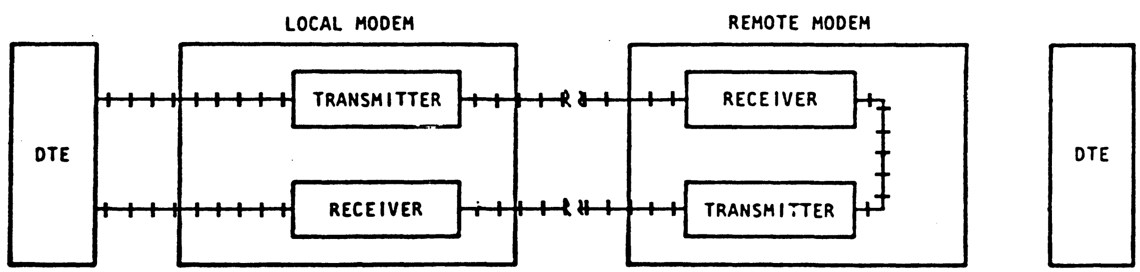


Front Panel of Modem Showing Switch to Select Test Options



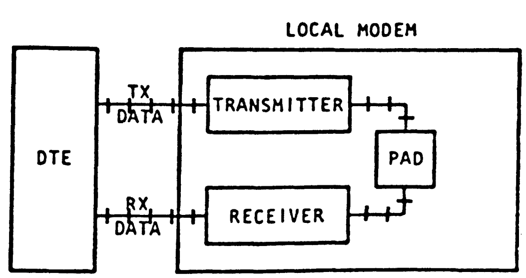
DIGITAL LOOPBACK LOOP 1

Digital loopback loop 1 tests the local DTE, cable and modem interface drivers. Loop 1 separates the normal data path from the modem transmitter and receiver circuits and connects transmit data to receive data; transmit clock to receive clock; and RTS to CTS and CD.



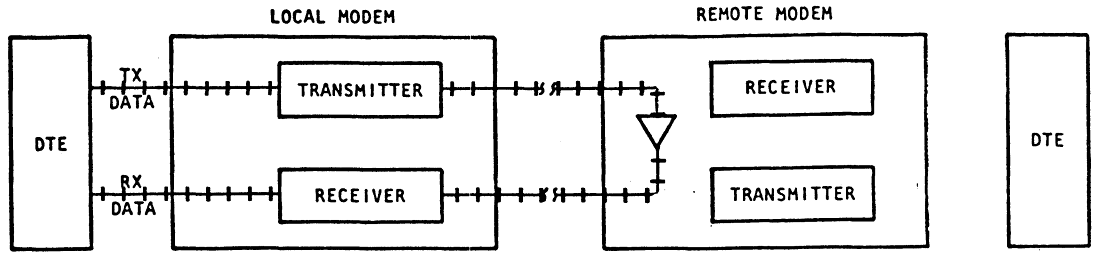
DIGITAL LOOPBACK LOOP 2

Digital loopback loop 2 allows the local DTE to test itself, local cable, local modem (totally), Telco lines (totally), and remote modem except digital interface drivers. The remote modem disconnects the remote DTE and connects receive data to transmit data, receive clock to transmit clock, CD to RTS.



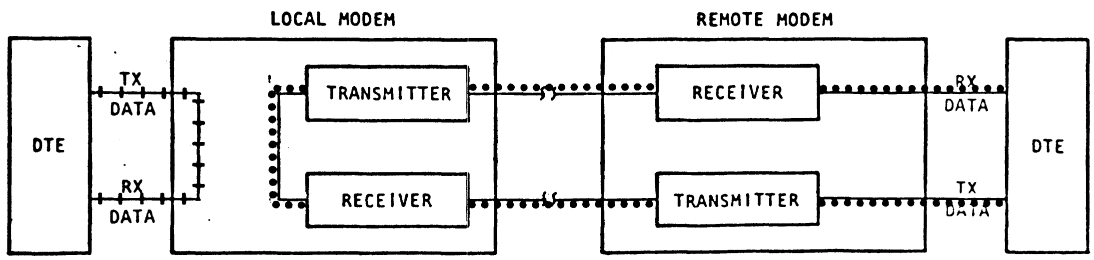
ANALOG LOOPBACK LOOP 3

Local loopback loop 3 tests the local DTE, cable, and local modem excluding Telco line interface. The modems modulated signal runs through a nominal 10dB pad to the receiver section of the modem. The purpose of the pad is to prevent receiver saturation caused by too high of a transmit signal level.



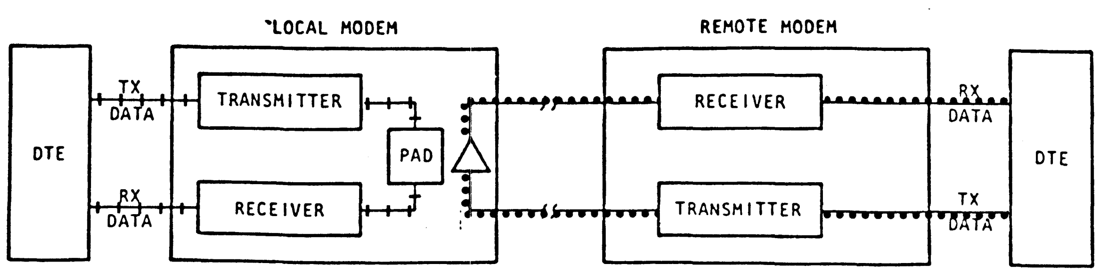
ANALOG LOOPBACK LOOP 4

Analog loopback 4 allows the local DTE to test itself, local cable, local modem (totally), Telco lines (totally), and the Telco interface on the remote modem. The remote modem disconnects the signal paths to the transmitter and receiver circuits and connects the receiver line through a 12db amplifier to the transmit line.



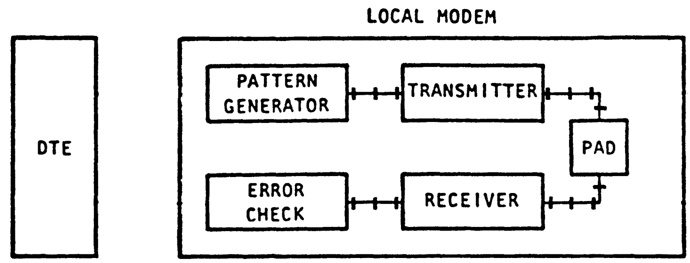
DIGITAL LOOPBACK LOOP 5

Digital loopback loop 5 (also known as bilateral digital loopback) combines the features of loop 1 and loop 2 at the local modem. The local DTE can test the local DTE, cable, and modem digital interface. The remote DTE can test the remote DTE, cable, remote modem, Telco lines, and local modem excluding the digital interface.



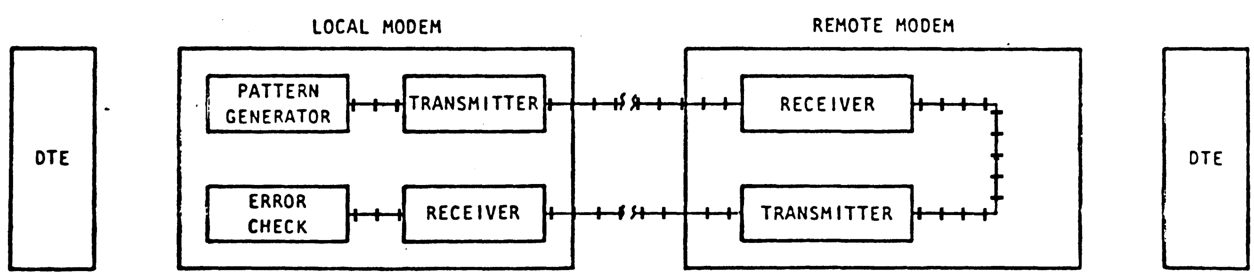
ANALOG LOOPBACK LOOP 6

Analog loopback loop 6 (also known as bilateral analog loopback) combines the test features of analog loopback loop 3 and loop 4 in the local modem. The local DTE can test the local DTE, cable, and local modem except Telco interface circuits. The Remote DTE can test the remote DTE, cable, Telco line ,and the local modem Telco circuits.



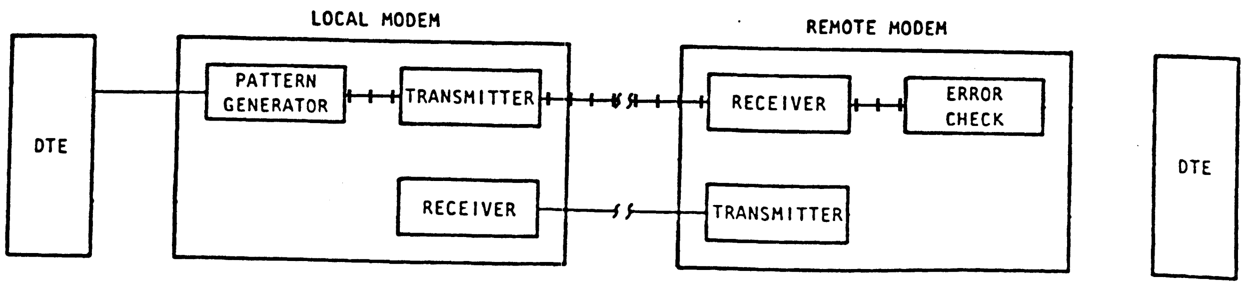
ST Loop 3

ST (self test) loop 3 is similar to analog loop 3 except the local modem disconnects. The local DTE connects its own internal test pattern generator and error detection circuits. This test quickly checks out 90% of the modem functions to determine if the modem is functioning properly. ST loop 3 is normally performed before any other modem tests are run.



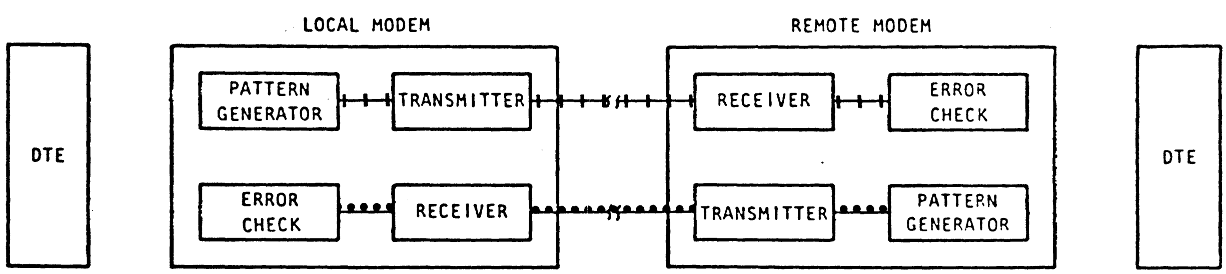
ST Loop 2

ST (self test) loop 2 is similar to analog loop 2 except the local modem is doing the testing instead of the local DTE. This test is normally done when the local DTE can not perform loopback tests to itself or used in problem isolation.



DT 1

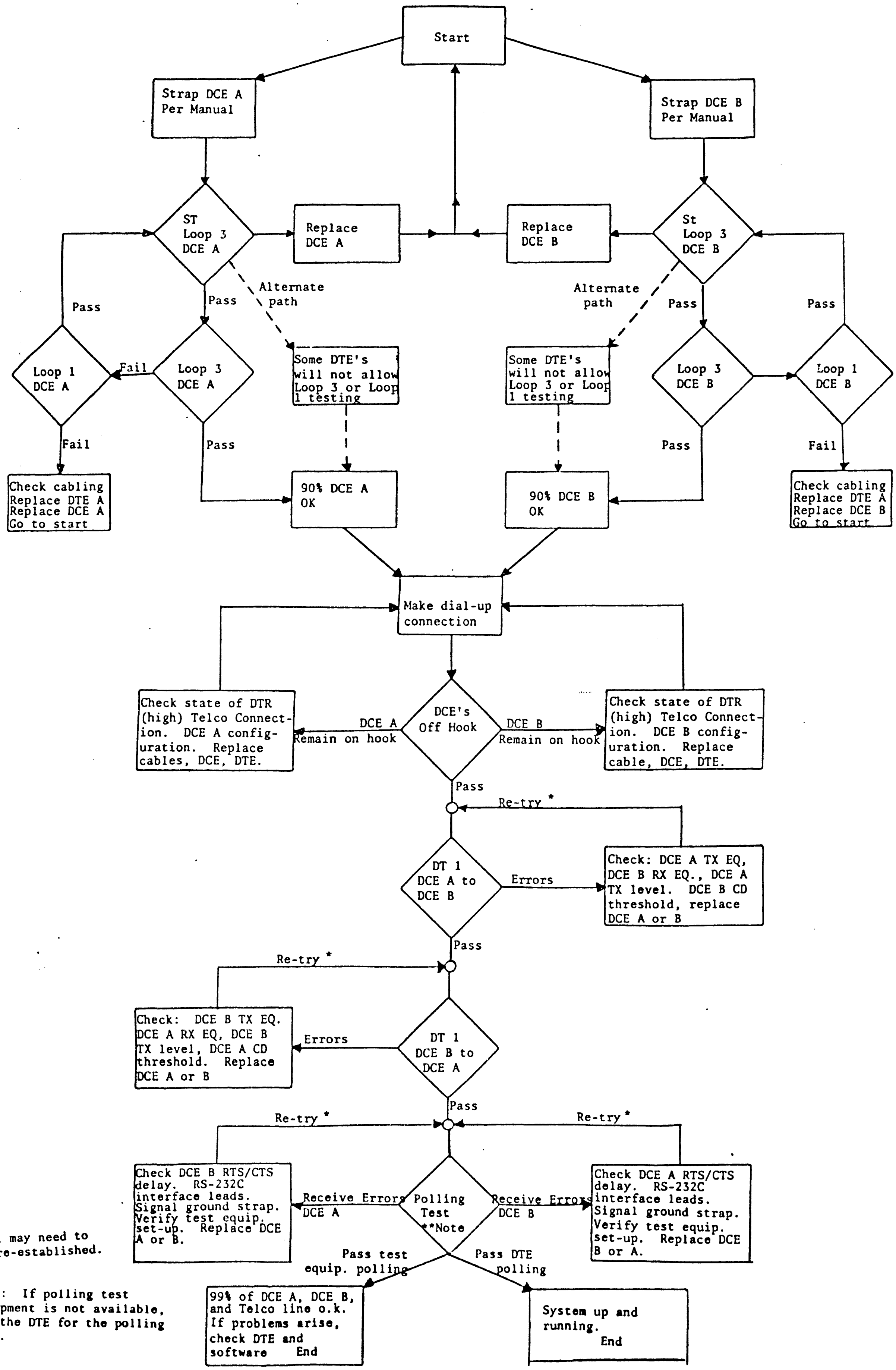
DT 1 is normally used on half duplex dial-up modems to set equalizer straps on initial installation. The local modem disconnects the local DTE and connects the test pattern generator circuits to the modem transmitter. The remote modem disconnects the remote DTE and connects the error check circuits. Once communications is verified, the test would be reversed. This testing is also known as receive only test.



DT 2

DT2 - (end to end testing) connects the test pattern generator of the local modem to the remote modems error checks circuits and vice versa. This provides complete modem to modem full duplex communication testing of both modems (except digitial interface) and the Telco lines. This test is normally used in determining modem connection and operation.

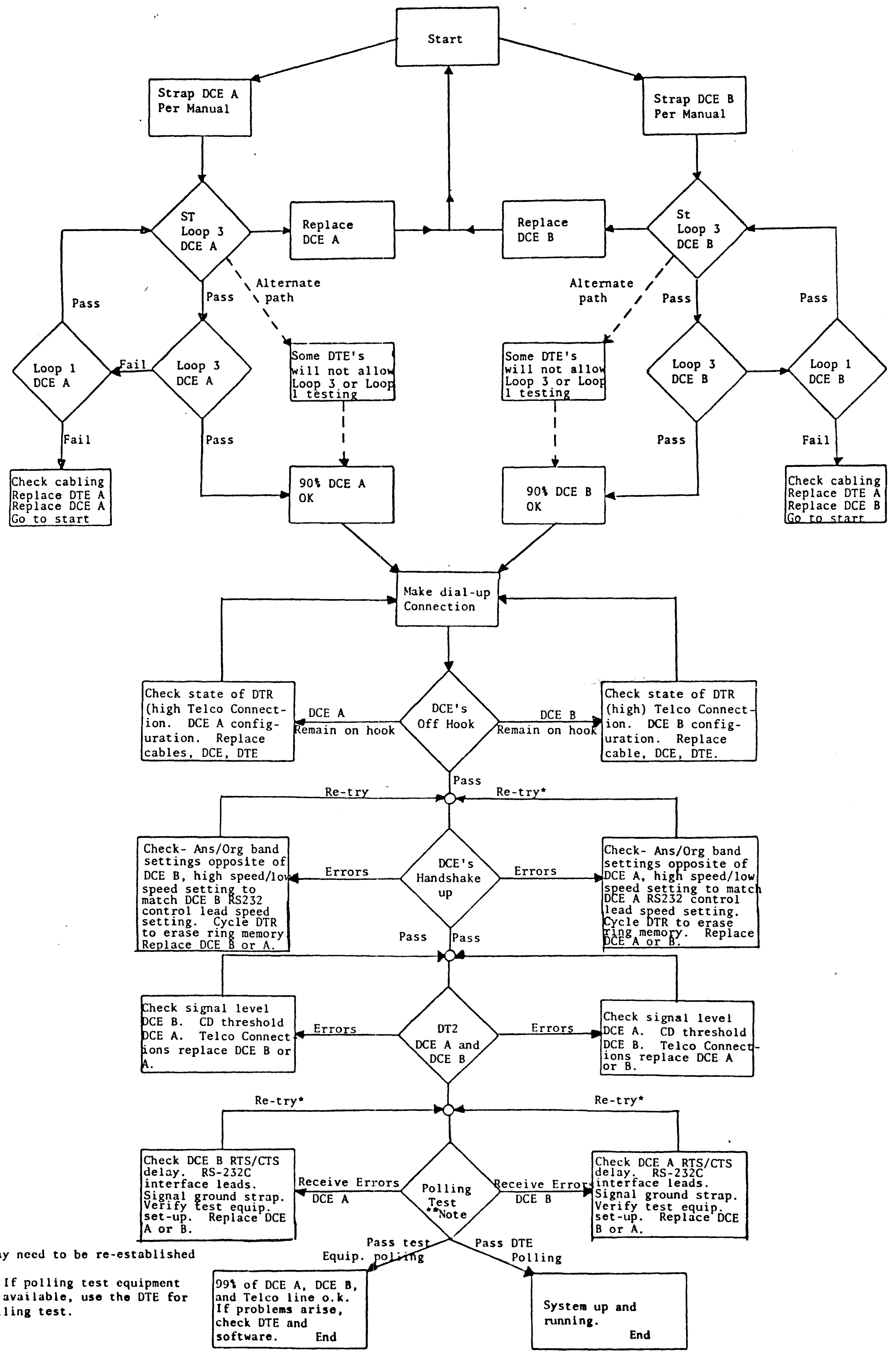
2 Wire PSTN HDX Modem



*Call may need to be re-established.

**Note: If polling test equipment is not available, use the DTE for the polling test.

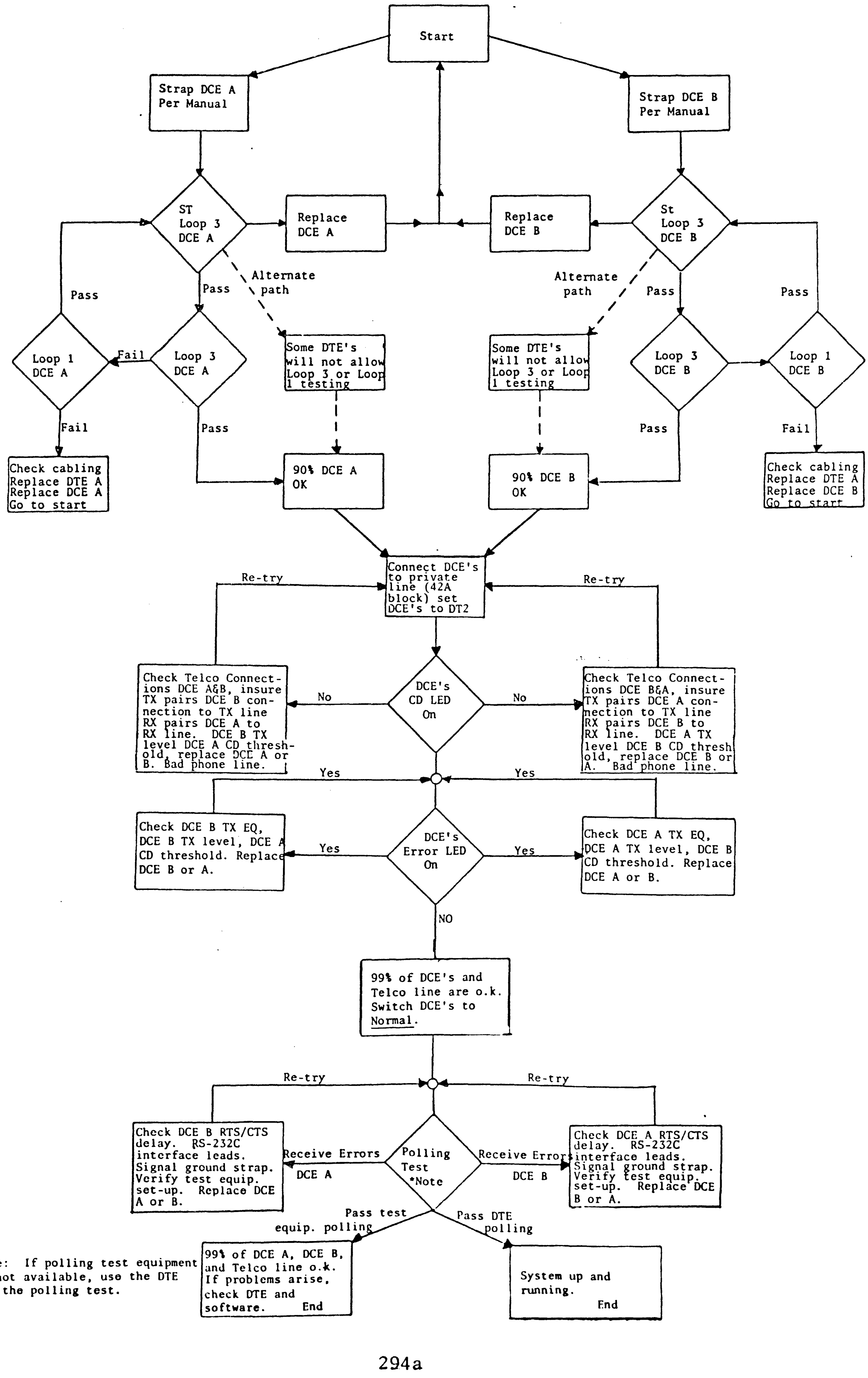
2 Wire PSTN FDX Modem



*Call may need to be re-established

**Note: If polling test equipment is not available, use the DTE for the polling test.

4 Wire Private Line



*Note: If polling test equipment is not available, use the DTE for the polling test.

Appendix A

A Listing of
Abbreviations, Acronyms,
Specifications and Standards
Utilized in Data Communications

A-1
ABBREVIATIONS AND ACRONYMS

ABT	Abort Timer or Answer Back Tone
A/D	Analog/Digital
ACF	Advanced Communications Function
ACK	Acknowledgement, positive
ACR	Abandon Call and Retry
ACU	Automatic Calling Unit
ADCCP	Advanced Data Communications Control Procedure
ADP	Automatic Data Processing
AGC	Automatic Gain Control
ALU	Arithmetic Logic Unit
AM	Amplitude Modulation
APL	A Programming Language
ARQ	Automatic Request for Repetition (IBM)
ASCII	American Standard Code for Information Interchange (7 level)
ASR	Automatic Send/Receive (teleprinters)
AVD	Alternate Voice/Data
Basic	Beginners All Symbolic Instruction Code
Baudot	Teleprinter Code (5 level)
BCC	Block Check Character
BCD	Binary Coded Decimal
BDLC	Burroughs Data Link Control
BDN	Bell Data Network (planned)
BER	Bit Error Rate
BERT	Bit-Error-Rate-Test (set)
Bit	Binary Digit
Bit/s or bps	Bits per second
BLU	Basic Link Unit
BSC	Binary Synchronous Communications
BTAM	Basic Telecommunications Access Method (IBM)
BTU	Basic Transmission Unit
CAI	Computer Assisted Instruction
CBT	Computer-Based Terminal
CBX	Computerized Private Branch Exchange
CCDN	Corporate Consolidated Data Network (IBM)
CCF	Communications Control Field
CCITT	International Consultative Committee for Telegraphy and Telephony
CCL	Communications Control Language
CCT	Coupler Cut Through
CCU	Communications Control Unit
CDCCP	Control Data Communications Control Procedure (Control Data Corp.)
CDF	Communications-Data Field
CMOS	Complementary Metal Oxide Semiconductor
CPH	Characters Per Hour
CPODA	Contention Priority-Oriented Demand Assignment (protocol)
CPU	Central Processing Unit
Coax	Coaxial Cable
COBOL	Common Business-Oriented Language
COM	Computer Output Microfilm
Comsat	Communications Satellite Corp.
COS	Call Originate Status
CPOL	Communications Procedure-Oriented Language
CR	Carriage Return
CRC	Cyclic Redundancy Checking
CRQ	Call Request
CRT	Cathode Ray Tube
CTAK	Cipher Text Auto Key
CTS	Clear To Send
Cybernet	Network of Control Data Corp.
DA	Data Available
DAA	Data Access Arrangement (AT&T)
DAL	Data Access Line
DAP	Data Access Protocol
DASD	Direct Access Storage Device
Dataset	Synonym for Modem (see Modem)
Datel II	RCA Global Communication Data Service in Conjunction with Telenet
dB, db	Decibel
DBMS	Database Management System
DBS	Database Service (WUI)
DCE	Data Circuit-Terminating Equipment or Data Communications Equipment
DCF	Distributive Computing Facility (Bank of America)
DCPSK	Differentially Coherent Phase-Shift Keying
DCS	Distributed Computing System
DDCMP	Digital Data Communications Message Protocol (Digital Data Corp.)
DDD	Direct Distance Dialing
DDP	Distributed Data Processing
DDS	Dataphone Digital Service (AT&T)
Decnet	Network of Digital Equipment Corp.
DES	Data Encryption Standard
DLC	Data Link Control

DLCF	Data Link Control Field
DLO	Data Line Occupied
DMA	Direct Memory Access
DMEP	Data-Network Modified Emulator Program (Cambridge Telecommunications Inc.)
DNA	Digital Network Architecture (Digital Equipment Corp.)
Domsat	Domestic Satellite Service
DOS	Disk Operating System
DP	Dial Port
DPR	Digit Present
DRS	Data Rate Selector
DSC	Direct Satellite Communications
DSDS	Dataphone Switched Digital Service (AT&T)
DSE	Distributed System Environment
DSR	Data Set Ready
DSU	Data Service Unit
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
DTS	Digital Tandem Switch
EBCDIC	Extended Binary Coded Decimal Interchange Code (8 level)
ECOS	Extended Communications Operating System (Harris Corp.)
EDP	Electronic Data Processing
EFT	Electronic Funds Transfer
EIA	Electronic Industries Association
EIES	Electronic Information Exchange System (New Jersey Institue of Technology)
EOA	End of Address
EOM	End of Message
EON	End of Number
EOT	End of Text or End of Transmission
EPROM	Erasable Programmable Read Only Memory
ESS	Electronic Switch System
FAX	Facsimile
FCC	Federal Communications Commission
FDX	Full-Duplex Transmission
FDM	Frequency-Division Multiplexer
FEC	Forward Error Correction
FED-STD	Federal Standard (see Appendix A-6)
FF	Form Feed
FGND	Frame Ground
FHD	Fixed-Head Disk
FIPS	Federal Information Processing Standards
FIGS	Figures Shift (teleprinters)
FM	Frequency Modulation
FOC	Fiber Optics Communications
FORTRAN	Formula Translation
Fox message	Test message (The quick brown fox jumps over the lazy dog) 0123456789
FSK	Frequency-Shift Keying

FX	Foreign Exchange
GPD	General Purpose Discipline (first IBM data link control)
HASP	Houston Automatic Spooling Priority
HDLC	High-level Data Link Control
HDX	Half-duplex Transmission
HiD/LoD	High-Density/Low-Denisty Tariff
HN	Host to Network
Hz	Hertz (cycles per second)
IBM TSS	Timesharing System (IBM network)
IMP	Interface Message Processor
IMS	Information Management System (IBM)
Infonet	Network of Computer Sciences Corp.
Intelsat	International Satellite Service
I/O	Input/Output
IPL	Initial Program Load
IPN	Instant Private Network
IRC	International Record Carrier
IS	International Standard (See Appendix A-3)
IT	Intelligent Terminal
ITDM	Intelligent Time-Division Multiplexer
ITS	Invitation To Send
JCL	Job Control Language
KAK	Key-Auto-Key
KAU	Keystation Adapter Unit
KDS	Keyboard Display Station
KSR	Keyboard Send/Receive
LCD	Line Current Disconnect
LED	Light-Emitting Diode
LF	Line Feed
LDM	Limited-Distance Modem
LIU	Line Interface Unit
LIM	Line Interface Module
LO	Line Occupancy
LRC	Longitudinal Redundancy Check
LSD	Line-Sharing Device or Line Signal Detector
LSI	Large-Scale Integrated (circuit)
LTRS	Letters Shift (teletypewriters)
MAN	Manual
MD	Multiple Dissemination
MDS	Multiple Dataset System
MHD	Moving-Head Disk
MHP	Message-Handling Processor (Bank of America)
MICR	Magnetic Ink Character Recognition
MIU	Multistation Interface Unit
MNCS	Multipoint Network-Control System
Modem	Modulator/Demodulator
MOS	Metal Oxide Semiconductor
MPCC	Multiprotocol Communications Controller
MP	Modem Port
MPL	Multischedule Private Line
MSI	Medium-Scale Integrated (circuit)

MT	Measured Time
MTBF	Mean Time Between Failures
MTS	Message Telecommunications Services (AT&T)
MTTR	Mean Time To Repair
MUX	Multiplexer
MVS	Multiple Virtual Storage
NAK	Negative Acknowledgement
NAM	Network Access Method (Control Data Corp.)
NBS	National Bureau of Standards
NC	Network Connect
NCP	Network Control Program (IBM)
NCR-DNA	NCR Corp. - Distributed Network Architecture
NCS	National Communications Systems (Department of Defense)
NDT	Net Data Throughput
NMC	Network Management Center
NRZ	Non-Return to Zero (Waveform)
NSP	Network Services Protocol (Digital Equipment Corp.)
NTPF	Number of Terminals Per Failure
OCR	Optical Character Recognition
Octopus	Network of Control Data Corp.
OH	Off Hook
OS	Operating System
OSWS	Operating System Workstation
PABX	Private Automatic Branch Exchange
PAD	Packet Assembler/Disassembler
PAM	Pulse Amplitude Modulation
PBX	Private Branch Exchange
PC	Printed Circuit (Board)
PCM	Pulse-Code Modulation
PFEP	Programmable Front-End Processor
PLL	Phase Locked Loop
PIU	Path Information Unit
PM	Phase Modulation
PMS	Public Message Service (WU)
PMX	Packet Multiplexer
PND	Present Next Digit
PSC	Public Service Commission
PSE	Packet Switching Exchange
PSK	Phase Shift Keying
PROM	Programmable Read Only Memory
PRTM	Printing Response-Time Monitor
PTT	Postal Telegraph and Telephone Agencies (Europe)
PUC	Public Utilities Commission
PWI	Power Indicator
QAM	Quadrature Amplitude Modulation
QTAM	Queued Telecommunications Access Method (IBM)

RAD	Random Access Method
RAM	Random Access Memory
RI	Ring Indicator
RCAC	Remote Computer Access Communications Service
RCD	Receiver-Carrier Detector
RCV	Receiver
RDC	Remote Data Concentrator
RLSD	Received Line Signal Detector
RJE	Remote Job Entry
RMS	Root Mean Square
RO	Receive Only
ROM	Read Only Memory
ROTR	Receive-Only Typing Reperforation
RPC	Registered Protective Circuitry
RPG	Report Program Generator
RPQ	Request to Price Quotation
RS	Recommended Standard (EIA) (See Appendix A-5)
RTS	Request To Send
RU	Request/Response Unit
SCC	Satellite Communications Controller or Specialized Common Carrier
SCPC	Single Channel Per Carrier
SCTO	Soft Carrier Turn Off
SDLC	Synchronous Data Link Control (IBM)
SGND	Signal Ground
SH	Switch Hook
SID	Swift Interface Device (See Swift)
SIMP	Satellite Information Message Protocol
SMRT	Signal Message Rate Timing
SNA	Systems Network Architecture (IBM)
SNAP	Standard Network Access Protocol
SNR	Signal/Noise Ratio
SOH	Start Of Header
SOM	Start Of Message
SP	Space Character
SPOOL	Simultaneous Peripheral Operation On Line (Now an accepted term)
SQD	Signal Quality Detector
STR	Synchronous Transmit Receive (4 level code, IBM)
STX	Start of Text
SU	Signalling Unit
SVD	Simultaneous Voice/Data
TAC	Telenet Access Controller (Telenet Corp.)
TC	Terminal Controller
TCAM	Telecommunications Access Method
TCU	Transmission Control Unit
TDM	Time-Division Multiplexer
TDMA	Time-Division Multiple Access
TELCO	Telephone Company
Telex	Teleprinter Exchange Service (WU)

TMU	Transmission Message Unit
TNS	Transaction Network Service (AT&T)
TSO	Timesharing Option
TTL	Transistor-to-Transistor Logic
TTY	Teletypewriter
TUCC	Triangle University Computing Center
TWX	Teletypewriter Exchange Service
Tymnet	Timeshare Inc. Network
UART	Universal Asynchronous Receiver/ Transmitter
USASCII	United States of America Standard Code for Information Interchange (identical to ASCII)
USITA	United States Independent Telephone Association
USOC	Universal Service Ordering Code
V.	CCITT Code Designation (See Appendix A-2)
VAC	Value Added Carrier
VAN	Value Added Network
VIP	Visual Information Projection
VM	Virtual Memory
V+TU	Voice Plus Teleprinter Unit
VS	Virtual Storage
VSPC	Visual Storage Personal Computing (IBM)
VTAM	Virtual Telecommunications Access Method (IBM)
WATS	Wide Area Telecommunications Service (AT&T)
WPM	Words Per Minute
WRU	Who-are-you?/character
WUI	Western Union International
X-Off	Transmitter Off
X-On	Transmitter On
X.	CCITT Recommendation Designation (See Appendix A-4)
XMIT	Transmit
XTC	External Transmit Clock

A-2
CONSULTATIVE COMMITTEE FOR INTERNATIONAL TELEPHONE AND TELEGRAPH

V.1	Equivalence between binary notation symbols and the significant conditions of a two-condition code
V.2	Power levels for data transmission over telephone lines
V.3	International Alphabet No. 5
V.4	General structure of signals of International Alphabet No. 5 code for data transmission over the public telephone network
V.6	Standardization of data-signalling rates for synchronous data transmission of leased telephone-type circuits
V.10(X.26)	Electrical characteristics for unbalanced double current interchange circuits for general use with integrated circuit equipment in the field of data communications (and provisional amendments, May 1977)
V.11(X.27)	Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications (and provisional amendments, May 1977)
V.15	Use of acoustic coupling for data transmission
V.19	Modems for parallel data transmission using telephone signalling frequencies
V.20	Parallel data transmission modems standardized for universal use in the general switched telephone network
V.21	200-baud modem standardized for use in the general switched telephone network
V.22	1200 bps asynchronous, full duplex modem for the switched network
V.23	600/1200 baud modem standardized for use in the general switched telephone network
V.24	List of definitions for interchange circuits between data terminal equipment and data circuit-terminating equipment (and provisional amendments, May 1977)
V.25	Automatic calling and/or answering equipment on the general switched telephone network, including disabling of echo suppressors on manually established calls
V.26	2400 bits per second modem standardized for use on four-wire leased circuits
V.26bis	2400/1200 bits per second modem standardized for use in the general switched telephone network
V.27	4800 bits per second modem standardized for use on leased circuits
V.27bis	4800 bits per second modem with automatic equalizer standardized for use on leased circuits
V.27ter	4800/2400 bits per second modem standardized for use in the general switched telephone network
V.28	Electrical characteristics for unbalanced double-current interchange circuits
V.29	9600 bits per second modem for use on leased circuits
V.31	Electrical characteristics for single-current interchange circuits controlled by contact closure
V.35	Data transmission at 48 kilobits per second using 60-108-kHz group-band circuits
V.36	Modems for synchronous data transmission using 60-108-kHz group-band circuits
V.54	Loop test devices for modems (and provisional amendments, May 1977)

A-3
INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO 646-1973	7-bit coded character set for information processing interchange
ISO 1155-1973	Information processing - Use of longitudinal parity to detect errors in information messages
ISO 1177-1973	Information processing - Character structure for start/stop and synchronous transmission
ISO 1745-1975	Information processing - Basic mode control procedures for data communications systems
ISO 2022-1973	Code extension techniques for use with ISO 7-bit coded character sets
ISO 2110-1972	Data communication - Data terminal and data communication equipment - interchange circuits - assignment of connector pin numbers
ISO 2111-1972	Data communication - Basic Mode control procedures - Code-independent information transfer
ISO 2593-1973	Connector pin allocations for use with high speed data terminal equipment
ISO 2628-1973	Basic mode control procedures - complements
ISO 2629-1973	Basic mode control procedures - Conversational information message transfer
ISO 3309-1976	Data communication - High level data link control procedures - Frame Structure

A-4
AMERICAN NATIONAL STANDARDS INSTITUTE

X3.1	Synchronous Signalling Rates for Data Transmission
X3.4	Code of Information Interchange
X3.15	Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission
X3.16	Character Structure and Character Parity Sense for Serial-by-Bit Data Communication Information Interchange
X3.24	Signal Quality at Interface between Data Processing Technical Equipment for Synchronous Data Transmission
X3.25	Character Structure and Character Parity Sense for Parallel-by-Bit Communication in American National Standard Code for Information Interchange
X3.28	Procedures for the use of the Communication Control Characters of American National Standard Code for Information Interchange in Specific Data Communication Links
X3.36	Synchronous High Speed Data Signalling Rates between Data Terminal Equipment and Data Communication Equipment
X3.41	Code Extension Techniques for use with 7-Bit Coded Character Set of American National Standard code for Information Interchange

X3.44	Determination of Performance of Data Communication Systems
X3.57	Structure for Formatting Message Headings for Information Interchange Using The American National Standard Code for Information Interchange for Data Communication System Control
X.1	International user classes of service in public data networks
X.2	International user facilities in public data networks
X.3	Packet assembly/disassembly facility (PAD) in a public data network
X.4	General structure of signals of International Alphabet No. 5 code for data transmission over public data networks
X.20	Interface between data terminal equipment and data circuit-terminating equipment for start-stop transmission services on public data networks
X.20bis	V.21 - compatible interface between data terminal equipment and data circuit terminating equipment for start-stop transmission services on public data networks
X.21	General purpose interface between data terminal equipment and data circuit-terminating equipment for synchronous operation on public data networks
X.21bis	Use on public data networks of data terminal equipment which is designed for interfacing to synchronous V-series modems
X.24	List of definitions of interchange circuits between data terminal equipment and data circuit-terminating equipment on public data networks
X.25	Interface between data terminal equipment and data circuit-terminating equipment for terminals operating in the packet mode on public data networks (and provisional amendment, April 1977)
X.26	Electrical characteristics for unbalanced double current interchange circuits for general use with integrated circuit equipment in the field of data communications (identical to V.10)
X.27	Electrical characteristics for balanced double current interchange circuits for general use with integrated circuit equipment in the field of data communications (identical to V.11)
X.28	DTE/DCE interface for a start/stop mode data terminal equipment accessing the packet assembly/disassembly facility (PAD) on a public data network situated in the same country
X.29	Procedures for exchange of control information and user data between a packet mode DTE and a packet assembly/disassembly facility (PAD)
X.92	Hypothetical reference connections for public synchronous data networks
X.95	Network parameters in public data networks
X.96	Call progress signals in public data networks

A-5 ELECTRONIC INDUSTRIES ASSOCIATION

RS-232C	Interface between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange
RS-269B	Synchronous Signaling Rates for Data Transmission

RS-334	Signal Quality at Interface between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission
RS-363	Standard for Specifying Signal Quality for Transmitting and Receiving Data Processing Terminal Equipment using Serial Data Transmission at the Interface with Non-Synchronous Data Communication Equipment
RS-366	Interface between Data Terminal Equipment and Automatic Calling Equipment for Data Communication
RS-404	Standard for Start-Stop Signal Quality between Terminal Equipment and Non-Synchronous Data Communication Equipment
RS-410	Standard for the Electrical Characteristics of Class A Closure Interchange Circuits
RS-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
RS-423	Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits
RS-449	General Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial-Binary Data Interchange
IEB-5	Industrial Electronics Bulletin No. 5, a tutorial paper on signal quality at Interface
IEB-9	Industrial Electronics Bulletin No. 9, application notes for EIA Standard RS-232C
IEB-12	Industrial Electronics Bulletin No 12, application notes on interconnection between interface circuits using RS-449 and RS-232C

A-6
FEDERAL STANDARDS

FED-STD-1001	High Speed Synchronous Signaling Rates between Data Terminal Equipment and Data Circuit Terminating Equipment
FED-STD-1002	Time and Frequency Reference Information
FED-STD-1003	Bit Oriented Data Link Control Procedures
FED-STD-1005	2400 BPS Modem
FED-STD-1006	4800 BPS Modem
FED-STD-1010	ASCII Bit Sequencing for Serial-by-Bit Transmission
FED-STD-1011	Character Structure for Serial-by-Bit ASCII Transmission
FED-STD-1012	Character Structure for Parallel-by-Bit ASCII Transmission
FED-STD-1013	Data Terminal Equipment to Data Circuit-Terminating Equipment Synchronous Signalling Rates using 4KHz Circuits
FED-STD-1020	Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits
FED-STD-1030	Electrical Characteristics of Balanced Voltage Digital Interface Circuits

Appendix B

Glossary of Data Communications Terminology

Datacomm glossary penetrates the jargon

Use this listing of datacomm definitions to unravel the technology's specialized vocabulary.

Whether you use it as a reference or an introduction, this compilation of terms will prove a handy guide to datacomm concepts. Adapted with permission from *Data Communications, A User's Guide,* by Ken Sherman (Reston Publishing Co, Reston, VA, 1980), it will help clarify your understanding of a complex and burgeoning field.

ACD (automatic call distributor)—A switching system that automatically distributes incoming calls to a centralized group of receivers in the sequence in which the calls are received. It holds calls until a receiver is available.

AC signaling—Using ac signals or tones to transmit data and/or control signals.

Acoustic coupler—A sound transducer connected to a modem that permits use of a telephone handset as a connection to the telephone-company network for data-transmission purposes.

ACU (automatic calling unit)—A device that automatically places a telephone call upon receiving information from a data-processing device.

Algorithm—A prescribed set of well-defined rules or processes for finding a problem's solution.

Alphanumeric—Consisting of letters and numbers.

Alternate route—A secondary communication path used to reach a destination when the primary one is unavailable.

AM (amplitude modulation)—Transmission of information on a communication line by varying the voltage level (amplitude).

Ambient noise—Interference present in a communication line at all times.

Amplitude variation (ripple)—Unwanted signal-voltage variations at different frequencies on a communication line.

Answer back—A signal from a receiving data-processing device in response to a transmitting one's request indicating that the receiver is ready to accept or has received data.

Application program—A computer program that performs a data-processing function rather than a control operation.

ARQ (automatic retransmission request)—An error-detection and -correction technique that attempts a retry upon detecting an error.

ASCII (American Standard Code for Information Interchange)—A data-communication code set.

ASR—Automatic send/receive.

Asynchronous—Not synchronized by a clocking signal; in code sets, character codes containing start and stop bits.

ATC (automated technical control)—A computer system used to maintain control of a data-communication network.

Attenuation—Loss of communication-signal energy.

Automatic dialer—A device that automatically dials telephone numbers on a network.

AWG (American Wire Gauge)—Wire-size standard.

Backup—The hardware and software resources available to recover after a degradation or failure of one or more system components.

Balanced circuit—A circuit terminated by a network whose impedance balances that of the line, resulting in negligible return losses.

Balancing network—Electronic circuitry used to match 2-wire to 4-wire facilities, sometimes called a hybrid. The balancing is necessary to maximize power transfer and minimize echo.

Bandwidth—The information-carrying capability of a communication line or channel.

Baseband—The frequency band that information-bearing signals occupy before they combine with a carrier in the modulation process.

Base group—Twelve communication-set paths capable of carrying the human voice on a telephone set; a unit of frequency-division-multiplexing systems' bandwidth allocation.

Baud—A data-communication-rate unit used similarly to bits per second (bps) for low-speed data: the number of signal-level changes per second (regardless of the information the signals contain).

Baudot—A 5-level code set; its formal name is the International Telegraph Alphabet (ITA) #2.

BCH—An error-detecting and -correcting technique used by communication receivers.

Beam—Microwave radio systems that use ultrahigh or superhigh frequencies (UHF, SHF) to carry communications where the signal is a narrow beam rather than a broadcast signal.

BERT (bit error-rate testing)—Testing a data line with a pattern of bits that are compared before and after a transmission.

Bias—Communication-signal distortion related to bit timing.

Bit rate—The rate at which data bits are transmitted over a communication path, normally expressed in bits per second (bps); not to be confused with the data signaling rate (baud), which measures the rate of signal changes transmitted.

Bit stream—A continuous series of bits transmitted on a line.

Blank—A "no-information" condition in a data-recording medium or storage location. This vacancy can be represented by all spaces or all ZEROs, depending on the medium.

BLERT (block error-rate testing)—Testing a data line with groups of information arranged in transmission blocks.

Block—A set of contiguous bits and/or bytes that make up a definable quantity of information.

Blocking—Describes a condition in a switching system in which no paths or circuits are available to complete a call, resulting in a busy tone returned to the calling party. The term also refers to a denial or busy condition.

Block-multiplexer channel—A computer-peripheral multiplexer channel that interleaves blocks of data. (See **byte-multiplexer channel**; contrast with **selector channel**.)

Bridge—Equipment and techniques used to match circuits to each other, ensuring minimum transmission impairment. Bridging is normally required on multipoint data channels where several local loops or channels interconnect.

Broadband—Refers to transmission facilities whose bandwidth is greater than that available on voice-grade facilities. Also called wide band.

Broadcast—To send messages or communicate simultaneously with many or all points in a circuit.

BSC (Bisync)—An IBM-developed data-link-control procedure using character synchronization.

Buffer—A storage area for a data block.

Burst—A group of events occurring together in time.

Burst error—A series of consecutive errors in data transmission.

Bus—A connective link between multiple processing sites (colocated only), where any of the processing sites can transmit to any other, but only one way at a time.

Byte—A set of contiguous bits constituting a discrete item of information. Most common bytes are six or eight bits long.

Byte-multiplexer channel—A channel that interleaves bytes of data from different sources. (Contrast with **selector channel**.)

Cache memory—A high-speed computer memory that contains the instruction or sequence of instructions most likely to be executed next.

Call-setup time—The overall length of time required to establish a switched call between pieces of data-terminal equipment.

Carrier—An analog signal at a fixed amplitude and frequency that combines with an information-bearing signal in the modulation process to produce an output signal suitable for transmission.

Carrier system—A method of obtaining several channels from one communication path by combining them at the originating end, transmitting a wide-band or high-speed signal and recovering the original information at the receiving end.

CCITT (Consultative Committee for International Telephone and Telegraph)—An international standards group.

CERT (character error-rate testing)—Checking a data line with test characters.

Chain—A series of processing locations through which information must pass on a store-and-forward basis to reach a subsequent location.

Channel—A data-communication path.

Channel bank—Communication equipment that multiplexes, typically used for multiplexing voice-grade channels.

Character—A language unit consisting of bits.

Character parity—Adding an overhead bit to a character code to provide error-checking capability.

Circuit switching—A communication method in which an electrical connection between calling and called stations is established on demand for exclusive circuit use until the connection is released.

Clocking—Time - synchronizing communication information.

Cluster—A group of user terminals colocated and connected to one controller, through which each terminal accesses a communication line.

Coaxial cable—2-conductor wire whose longitudinal axes are coincident; cable with a noise shield around a signal-carrying conductor.

Common mode—A high-speed-modem interface name.

Communication-line controller—A hardware unit that performs line-control functions with a modem.

Compandor—A device used on some telephone channels to improve transmission performance. The equipment compresses the outgoing-speech volume range and expands the incoming volume range on a long-distance telephone circuit.

Concentrator—An electronic device that interfaces in a store-and-forward mode with multiple low-spe communication lines at a message level and then retransmits those messages to a processing site via one or more high-speed communication lines.

Conditioning—Applying electronic filtering elements to a communication line to improve its ability to support higher transmission data rates. (See **equalization.**)

Connecting block—A cable-termination block where access to circuit connections is available.

Contention—Competition for use of the same communication facilities; a line-control method in which terminals request or bid to transmit.

Control-line timing—Clock signals between a modem and a communication-line controller unit.

CPS (characters per second)—A data-rate unit.

CPU (central processing unit)—The computer control logic used to execute programs.

CRC (cyclic redundancy check)—An error-checking control technique utilizing a binary prime divisor that produces a unique remainder.

Crossbar—A type of widely used control-switching system using a crossbar or coordinate switch. Crossbar switching systems suit data switching because they have low-noise characteristics and can handle Touch-Tone dialing.

CTS (clear to send)—A control signal between a modem and a controller used to initiate data transmission over a communication line.

Cursor—A lighted area on a CRT screen used to indicate the next character location to be accessed.

CXR (carrier)—A communication signal used to indicate the intention to transmit data on a line.

DAA (Data Access Arrangement)—A telephone-switching-system protective device used to attach uncertified nontelephone-company-manufactured equipment to the carrier network.

Data base—A collection of electronically stored data records.

Data compression—A technique that provides for the transmission of fewer data bits than originally required without information loss. The receiving location expands the received data bits into the original bit sequence.

Data set—See **modem.**

Data switcher—A system used to connect network lines to a specific data-processing computer port.

dB (decibel)—Power- and voltage-level-measurement unit.

dBm—Power-level-measurement unit in the telephone industry based on 600Ω impedance and 1004-Hz frequency. 0 dBm is 1 mW at 1004 Hz terminated by 600Ω impedance.

DCE (data-communication equipment)—Equipment (such as a modem) installed at a user's premises that provides all the functions required to establish, maintain and terminate a connection and signal conversion and coding between the data-terminal equipment and the common carrier's line.

DDD (Direct Distance Dial)—The North American telephone dial system.

Dedicated line—A communication line that isn't dialed, also termed a leased or private line.

Delay distortion—Distortion that occurs on communication lines due to signals' different propagation speeds at different frequencies. Measured in microseconds of delay relative to the delay at 1700 Hz. This type of distortion doesn't affect voice communication but can seriously impair data transmissions.

Demodulator—A functional section of a modem that converts received analog line signals to digital form.

Dial up—The use of a rotary-dial or Touch-Tone phone to initiate a station-to-station call.

DMA—Direct memory access from I/O and peripheral controllers without going through the arithmetic processing unit.

DQM (data-quality monitor)—A device used to measure data bias distortion above or below a threshold.

DTE (data-termination equipment)—Equipment that constitutes the data source and/or data sink and provides for the communication control function protocol; it includes any piece of equipment at which a communication path begins or ends.

EBCDIC (Extended Binary Coded Decimal Interchange Code)—An 8-level code set used frequently in data communication.

Echo distortion—A telephone-line impairment caused by electrical reflections at distant points where line impedances are dissimilar.

EIA (Electronic Industries Association) RS-232—The standard interface between a modem and line controller for voice-grade communication lines.

Electronic Switching System (ESS)—A type of telephone switching system that uses a special-purpose digital computer to direct and control the switching operation. ESS permits custom-calling services such as speed dialing, call transfer and 3-way calling.

Encryption—The technique of modifying a known bit stream on a transmission line to make it appear like a random sequence of bits to an unauthorized observer.

Envelope delay—An analog line impairment where a variation of signal delay with frequency occurs across the data-channel bandwidth. (See **delay distortion.**)

Equalization—A technique used to compensate for distortions present on a communication channel. Equalizers add loss or delay to signals in inverse proportion to the channel characteristics. The signal response curve is then relatively "flat" and can be amplified to regain its original form. (See **distortion.**)

F1F2—A type of modem that operates over a half-duplex line (2-wire) to produce two subchannels at two different frequencies for low-speed full-duplex operation. (See **reverse channel.**)

Facility—A transmission path between two or more locations without terminating or signaling equipment. Adding terminating equipment would produce either a channel, a central-office line or a trunk.

FDM (frequency-division multiplexing)—A technique in which a data line's bandwidth is divided into different frequency subchannels. It permits several terminals to share the same line.

FE (format effectuation)—Characters of a code set used to format information to be sent for processing.

FEC (forward error correcting)—Used to describe equipment that corrects transmission errors at a receiver. The technique provides for transmission of additional information with the original bit stream so that if an error is detected, the receiver can recreate the correct information without a retransmission.

Fiber optics—A technology employing plastic or glass fibers that carry light representing information.

Filter—Electronic circuitry that blocks some signal components while allowing other components to pass through uniformly.

Firmware—A set of software instructions placed permanently or temporarily in a read-only memory (ROM).

Flag—A delimiting bit field used to separate portions of data.

Flexible disk (floppy disk)—A magnetic storage medium constructed of thin plastic.

FM (frequency modulation)—A method of transmitting digital information on an analog line by varying the carrier frequency.

Format—A message or data structure that allows identification of specific control codes or data by their position during processing.

Frequency offset—Analog-line frequency change, an impairment encountered on a communication line.

Frequency shift keying (FSK)—A form of frequency modulation in which the carrier frequency is made to vary or change in frequency precisely when a change in the state of a transmitted signal occurs.

Frequency stacking—Another name for FDM that reveals how the multiplexing is performed.

Front end—An auxiliary computer system that performs network-control operations, releasing the host computer system to process data.

Full duplex (FDX)—A 4-wire circuit or protocol that provides for simultaneous transmission in both directions between two points.

Full/full duplex—A protocol for a multidrop line that permits transmission from a master location to a slave site; the master location can also simultaneously receive a transmission from another slave site on that line.

Gain—The degree to which a signal's amplitude is increased. The amount of amplification realized when a signal passes through an amplifier or repeater, normally measured in decibels.

Gaussian noise—Noise whose amplitude is characterized by the Gaussian distribution, (eg, white noise, ambient noise, hiss).

Group channel—A unit or method of organization on telephone carrier (multiplex) systems. A full group is a channel equivalent to 12 voice-grade channels (48 kHz). A half group has the equivalent bandwidth of six voice-grade channels (24 kHz). When not subdivided into voice facilities, group channels can furnish high-speed data communication.

Guard frequency—Describes the frequencies between subchannels in FDM systems used to guard against subchannel interference.

Half duplex—A communication line consisting of two wires or employing a protocol capable of transmitting in only one direction at a time.

Hamming code—An FEC technique named for its inventor. It corrects single-bit errors.

Handshaking—Line-termination interplay to establish a data-communication path.

Harmonics—Frequencies that are multiples of a fundamental value.

Harmonic distortion—A data-communication-line impairment caused by erroneous frequency generation along the line.

HDLC (High Level Data-Link Control)—A CCITT standard data-communication line protocol.

Hit on the line—Describes errors caused by external interference, such as impulse noise resulting from lightning or man-made interference.

House cables—Conductors inside a building used to connect communication equipment to outside lines.

HRC (horizontal redundancy checking)—A validity-checking technique used on data-transmission blocks in which redundant information is included with the information to be checked.

Hybrid—See **balancing network.**

Impulse noise—A type of communication-line interference characterized by high amplitude and short duration.

Insertion loss—Signal-power loss resulting from connecting communication equipment with dissimilar impedance values.

Interference—Refers to unwanted occurrences on communication channels that result from natural or man-made noises and signals.

Intermodulation distortion—An analog-line impairment where two frequencies interact to create an erroneous frequency, which in turn distorts the data-signal representation.

ITDM (intelligent time-division multiplexer)—A multiplexer that assigns time slots on demand rather than on a fixed subchannel-scanning basis. Also termed a statistical multiplexer.

Jitter—Type of analog-communication-line distortion caused by a signal's variation from its reference timing position, which can cause data-transmission errors, particularly at high speeds. This variation can be in amplitude, time, frequency or phase.

Jumbo group—The highest FDM carrier-system multiplexing level; it contains 3600 voice-frequency (VF) or telephone channels (six master groups).

Leased line (private line, dedicated line)—A communication line for voice and/or data rented from a communication carrier.

Line protocol—A control program used to perform data-communication functions over network lines. Consists of both handshaking and line-control functions that move the data between transmit and receive locations.

Local loop—The access line from either a user terminal or a computer port to the first telephone office along the line path.

Logging—Recording data, such as error events or transactions, for future reference.

Long line—A communication line spanning a long distance relative to the local loop.

Loop current—A teletypewriter-to-line interface and operating technique that doesn't employ modems.

Loopback—Directing signals back toward the source at some point along a communication path.

LTS (line test set)—Analog-line test unit.

Main distribution frame (MDF)—The cable rack on which all distribution and trunk cables leading into a central office are terminated.

Message switching—Routing messages between three or more locations by store-and-forward techniques in a computer.

MG (master group)—An FDM carrier-multiplexing level containing 600 voice-frequency channels.

Microcode—A set of software instructions that execute a macro instruction.

MIL-188—A military interface between a modem and line controller equivalent to RS-232.

Modem (data set)—An acronym for a unit that *mo*dulates and *dem*odulates digital information from a terminal or computer port to an analog carrier signal for passage over an analog line.

Multiplexed line—A data-communication line equipped with multiplexers at each end.

Multipoint line—A communication line with several subsidiary controllers sharing time on the line under a central site's control.

Noise—A communication-line impairment inherent in the line design or induced by transient energy bursts.

On line—A direct connection between a remote terminal and a central processing site.

Open wire—Communication lines that aren't insulated and formed into cables, but are instead mounted on aerial crossarms on utility poles.

Packet-mode terminal—Data-terminal equipment that can control and format packets and transmit and receive them.

Packet switching—The transfer of data by means of addressed packets whereby interim point-to-point channels are available only during the transmission of one packet. The channel then becomes available for the transfer of packets from the same or other messages. Contrast with circuit switching, where the data network determines the end-to-end routing before the entire message transfer.

PAD (packet assembler/disassembler)—Equipment providing packet assembly and disassembly facilities.

Parity error—An error occurring when the results of the parity calculations at the transmit and receive ends of a system don't agree.

Passband filters—Filters used in modem design to allow only the frequencies within the communication channel to pass while rejecting all frequencies outside the channel.

PC (phase corrector)—A part of synchronous modems that adjusts the local data-clocking signal to match the incoming receive data sent by the remote clocking signal.

Phase jitter—An analog-line impairment caused by power and communication equipment along the line that shifts the signal phase relationship back and forth.

PM (phase modulation)—Variation of an analog signal's phase in direct relationship to digital input information.

Point-to-point—A communication line connected directly from one site to another.

Polling—A control message sent from a master site to a slave site that serves as an invitation to transmit data to the master site.

Primary center—A Class 3 telephone-switching office at the next level above toll center.

Privacy—The techniques used for limiting and/or preventing access to specific system information from otherwise authorized system users.

Propagation delay—The time necessary for a signal to travel from one point in a circuit to another.

Protocol—A formal set of conventions governing the format and control of inputs and outputs between two communicating processes, including handshaking and line discipline.

Pulse modulation—Modulating the characteristics of a pulse series in one of several ways to create an information-bearing signal. Typical methods involve modifying the pulses' amplitude (PAM), width or duration (PDM), or position (PPM). The most common pulse-modulation technique employed in telephone communications is pulse-code modulation (PCM), in which the system samples the information signals at regular intervals and transmits a series of pulses in coded form, representing the amplitude of the information signal at the sampling time.

Quadrature distortion—Analog-signal distortion frequently found in phase-modulation modems.

Reactance—Frequency-sensitive communication-line impairment causing loss of power and phase shifting.

Recovery—The actions required to bring a system to a predefined level of operation after a degradation or failure.

Regional center—A Class 1 telephone-switching office, the top level in the DDD system.

Response time—The time measured from the depression of a terminal's Enter key to the display of the first character of the response at that terminal site.

Reverse channel—An optional feature on some modems that provides simultaneous communication from the receiver to the transmitter on a 2-wire channel. It can be used for message transmission, circuit assurance or breaking and to facilitate certain forms of error control and network diagnostics. Also termed backward channel.

RTS (request to send)—An RS-232 control signal between a modem and user's digital equipment that initiates the data-transmission sequence on a communication line.

SDLC (Synchronous Data-Link Control)—An IBM data-communication message protocol.

Sectional center—A Class 2 telephone-switching office between a regional and a primary center.

Selector channel—A channel designed to operate with only one I/O device at a time. Once the I/O device is selected, a complete record transfers one byte at a time. (Contrast with **block-multiplexer channel.**)

Slicing level—A voltage or current level of a digital signal at which a ONE or ZERO can be determined.

Slot—A unit of time in a TDM frame during which a subchannel bit or character is carried to the other end of the circuit and extracted by the receiving TDM unit.

S/N (signal-to-noise) ratio—The relative power levels of a signal and noise on a communication line, expressed in decibels.

SRC (spiral redundancy checking)—A validity-checking technique for transmission blocks where the redundant information sent with the block for receiver checking is accumulated in a spiral-bit-position fashion.

Store and forward—A data-communication technique that accepts messages or transactions, stores them until they are validated and complete and then forwards them to the next location as addressed in the message or transaction header.

Streaming—A modem's condition when it is sending a carrier signal on a multidrop communication line and hasn't been polled.

Super group—The assembly of five 12-channel groups, for simultaneous modulation and demodulation, occupying adjacent bands in the spectrum. Can be used as 60 voice-grade or wide-band channels or combinations of both.

SYN (SYNC)—A bit or character used to synchronize a time frame in a time-division multiplexer. Also, a sequence used by synchronous modems to perform bit synchronization and by the line controller for character synchronization.

Synchronous modem—A line-termination unit that uses a derived clocking signal to perform bit synchronization with incoming data.

TDM (time-division multiplexing)—A data-communication technique for combining several lower speed channels into one facility or transmission path at a higher speed in which each low-speed channel is allotted a specific position in the signal stream based upon time. Thus, the information on the low-speed input channels is interleaved at higher speed on the multiplexed channel. At the receiver, the signals are separated to reconstruct the individual low-speed channels.

Telemetry—Transmission and collection of data obtained by sensing conditions in a real-time environment.

Text—The part of a message or transaction between the control information of the header and that of the trace section or tail that constitutes the information to be processed or delivered to the addressed location.

Thermal noise—A type of electromagnetic noise produced in conductors or in electronic circuitry that is proportional to temperature. (See **Gaussian noise.**)

Time sharing—A processing technique that permits multiple users to share resources simultaneously.

Toll center—A Class 4 telephone-switching office up one level from the end or serving office, named for the call-billing apparatus found there.

T/P (transaction processing)—A processing technique using on-line control programs and a remote terminal network so that inquiries and applications against a data base can be performed at any processing site where the data is stored. Routing is performed based on the content of the message that also contains the information to be processed.

Turnaround time—The time required for a modem to reverse the direction of transmission on a half-duplex line.

Uncontrolled terminal—A user terminal that is on line all the time and does not contain line-control logic for polling and calling.

VF (voice frequency)—Describes a telephone channel designed to carry the human voice.

VHF (very high frequency)—A radio carrier-frequency band (30 to 300 MHz) used in emergency situations for telephone and data communications.

VRC (vertical redundancy checking)—A method of character parity checking.

White noise—See **Gaussian noise** and **thermal noise.**

Wide band—Implies data speeds requiring the equivalent of more than one VF channel for operation; broadband. **EDN**

Article Interest Quotient (Circle One)
High 479 *Medium* 480 *Low* 481

Appendix C

FCC Adopted Standard Jack Arrangements

for

Data Equipment Connection

FCC ADOPTED STANDARD JACK ARRANGEMENTS FOR DATA EQUIPMENT CONNECTION

Type of Jack	Type of Connection	USOC Code	Application
A. Miniature 6-Position	Bridged Tip and Ring	RJ11C, RJ11W, RJ17C	1 & 2
	Bridged Tip and Ring Ahead of Key Telephone Line Circuit Plus A and A1	RJ12C, RJ12W	3
	Bridged Tip and Ring Behind Key Telephone Circuit Plus A and A1	RJ13C, RJ13W	4
	Bridged 2 Line Tip and Ring	RJ14C, RJ14W	5
	Bridged Tip and Ring With Mode Indication to A Series Connection Ahead of Bridged Connector	RJ16X	6
	Bridged Tip and Ring Ahead of All Equipment With Make Busy Control	RJ18C	7
	Bridged Tip and Ring Behind Key Telephone Line Circuit Plus A, A1, and Make Busy Control	RJ19C	8
	Bridged 3 Line Tip and Ring	RJ25C	9
B. Weatherproof	Bridged Tip and Ring	RJ15C	10
	Bridged Tip and Ring (Adapters)	RJA1X, RJA2X RJA3X	11
C. 50-Position Miniature Ribbon Jack	Bridged Tip and Ring	RJ21X	12
	Bridged Tip and Ring Ahead of Key Telephone Line Circuit Plus A and A1	RJ22X	13
	Bridged Tip and Ring Behind Key Telephone Line Circuit Plus A and A1	RJ23X	14
	Bridged Tip and Ring Behind Key Telephone Line Circuit Plus A And Common A1	RJ24X	15

Type of Jack	Type of Connection	USOC Code	Application
C. 50-Position Miniature Ribbon Jack (Cont)	Bridged Tip and Ring (DATA)	RJ26X, RJ27X	16
	Series Tip and Ring	RJ71C	17
	Series Tip and Ring Ahead of All Station Equipment	RJ31X	18
D. Miniature 8-Position Series Jack	Series Tip and Ring Ahead of One Station	RJ32X	19
	Series Tip and Ring Ahead of Key Telephone Line Circuit Plus A and A1	RJ33X	20
	Series Tip and Ring Behind Key Telephone Line Circuit Plus A and A1	RJ34X	21
	Series Tip and Ring Plus A and A1 Wired to Station Set Terminals	RJ35X	22
	Series Tip and Ring Plus MI and MIC	RJ36X	23
	Bridged 2 Line Tip and Ring With Exclusion On Line 1	RJ37X	24
	Series Tip and Ring Ahead of All Station Equipment With Continuity Leads	RJ38X	25
E. Miniature 8-Position Series Jack (Keyed)	Bridged Tip and Ring Plus MI and MIC	RJ41S, RJ45S (RJ41M, RJ45M)	26

1. Jacks RJ11C and RJ11W are normally associated with single line ancillary devices, telephone sets, or -9 dBm (permissive) modems and provide bridged connections to the tip and ring of a telephone line. RJ11C is surface or flush mounted for use with desk telephone sets, while RJ11W is used for wall mounted telephone sets.

2. Jack RJ17C provides a single line bridged connection of tip and ring to special telephone sets or ancillary equipment (e.g., ECG machines) in hospital critical care areas. Only registered equipment conforming to Article 517 of the 1978 National Electrical Code is permitted to connect to this jack arrangement. This jack differs from the RJ11C in that tip and ring appear on pins 1 & 6 rather than 3 & 4.

3. Jacks RJ12C and RJ12W are normally associated with one line of a key telephone system. They provide a bridged connection to the tip and ring of the telephone line and to key system A and A1 leads. The tip and ring conductors in the jack are connected ahead of the key telephone system line circuit. The RJ12C is surface or flush mounted for use with desk telephone sets while the RJ12W is for wall mounted telephone sets. Typically, these arrangements are used when registered ancillary equipment must respond to central office or PBX ringing.

4. Jacks RJ13C and RJ13W are normally associated with one line of a key telephone system. They provide a bridged connection electrically behind the key system line circuit to the tip and ring conductors and to the A and A1 leads. The RJ13C is surface or flush mounted for use with desk telephone sets while RJ13W is for wall mounted telephone sets. These arrangements are generally used when the registered ancillary equipment does not require central office or PBX ringing to function properly.

5. Jacks RJ14C and RJ14W provide for bridged connections to the tip and ring conductors of two separate telephone lines. The RJ14C is surfaced or flush mounted for use with desk telephone sets while the RJ14W is for wall mounted telephone sets.

6. Jack RJ16X provides a single line bridged tip and ring and is associated with -9 dBm (permissive) data arrangements that require mode indication for use with exclusion key telephone sets. The exclusion key telephone set requires a series jack, RJ36X (described under 8 position jacks) as its normal means of connection.

7. Jack RJ18C provides a bridged connection of single line tip and ring with make-busy leads MB MB1. When the registered equipment provides a contact closure between the MB and MB1 leads, a make busy indication is transmitted to the network equipment busying out the line from further incoming calls. It is recommended that the busy indication (contact closure) be provided while the line is in the idle state in order to reduce the possibility of interfering with a call that is in the ringing or talking state. The RJ18C is surface or flush mounted for use with desk telephone sets.

8. Jack RJ19C is normally associated with one line of a key telephone system. It provides a bridged connection of single line tip and ring behind a key system line circuit, with A and A1 lead control, and a direct connection for MB/MB1 make busy leads.

   When the modem provides a contact closure between the MB and MB1 leads, a make busy indication is transmitted to the network equipment busying out the line from further incoming calls. It is recommended that the busy indication (contact closure) be provided while the line is in the idle state in order to reduce the possibility of interfering with a call that is in the ringing or talking state. The RJ19C is surface or flush mounted for use with desk telephone sets.

9. Jack RJ25C provides for bridged connection to the tip and ring conductors of three separate telephone lines. The telephone company will wire the lines to the jack in the sequence designated by the customer. The RJ25C is surface or flush mounted for use with the desk telephone sets and ancillary devices.

10. Jack RJ15C is a weatherproof jack arranged to provide single line bridged connection to tip and ring. Jack RJ15C can be arranged for surface or flush mounting depending upon customer needs.

11. RJA1X and RJA3X are adapters used to adapt 4-position and 12-position jacks, respectively, to a 6-position miniature bridged jack (Figures 15 and 16). They provide bridged connections to the tip and ring of the telephone line. If A and A1 leads are already terminated in the 4- or 12-pin jack, they will appear in positions 2 and 5 in the adapter. If A and A1 leads are not involved, positions 2 and 5 are reserved for telephone company use.

RJA2X is an adapter that converts a single miniature jack to two miniature jacks. It provides a bridged connection to the tip and ring conductors of the telephone line. If A and A1 leads are already terminated in an existing miniature bridged jack, they will appear in positions 2 and 5 in both miniature bridged jacks in the adapters. If A and A1 leads are not provided, positions 2 and 5 are reserved for telephone company use.

12. Jack RJ21X provides bridged connections to tip and ring conductors of up to twenty-five telephone lines. The RJ21X is typically used with Traffic data Recording Equipment and Multiple Line Communication Systems. The user must specify the connection sequence for each line appearing in the jack.

13. Jack RJ22X can be associated with a telephone company-provided key telephone system when connection to several lines is required. It provides bridged connections of up to twelve telephone lines and their associated A and A1 leads. The tip and ring conductors in the jack are wired ahead of the line circuit in the key telephone system. This arrangement is used when the modem must respond to central office or PBX ringing.

14. Jack RJ23X is normally associated with a telephone company-provided key telephone system when connection is required to several lines. It is wired to provide bridged connections of up to twelve key system line circuits and associated A and A1 leads. It differs from and is prefered over the RJ22X, in that tip and ring conductors in the jack are wired behind the key system line circuits. This arrangement is typically used when the modem does not require central office or PBX ringing to function properly.

15. Jack RJ24X is normally associated with a telephone-company provided key telephone system. It is typically used with registered ancillary devices such as conferencing devices, music on hold, etc. It is wired to provide the same tip, ring, A, and A1 appearances as a standard five line key telephone set.

16. Jack RJ26X is a multiple line universal data jack for up to 8 lines in a 50-position miniature ribbon connector and accommodates either fixed loss loop (FLL) or programmed (P) types of data equipment. A switch, accessible to the customer, is provided on each line to select FLL or P type of operation. FLL equipment transmits at -4 + 1 dB with respect to one milliwatt and a pad is included in the data jack so that pad loss plus loop loss is nominally 8 dB. Programmed type data equipment adjusts its output power in accordance with a programming resistor in the data jack. By these means, signals from either FLL or P types of registered data equipment will arrive at the local telephone company central office at a nominal -12 dB with respect to one milliwatt for optimum data transmission.

    Jack RJ27X is a multiple line programmable data jack for up to 8 lines in a 50-position miniature ribbon connector and accommodates programmed data equipment only.

17. Jack RJ17C provides a multiple series arrangement of tip and ring. It is typically used with registered series devices such as toll restrictors, etc. Jack RJ17C can accommodate up to 12 circuits per jack (i.e., one tip and ring "in" and one tip and ring "out", 4 leads per circuit). This arrangement does not currently provide automatic restoration upon disconnection of registered equipment. Thus, a manual bridging plug is provided in order to maintain circuit continuity upon withdrawal of a registered plug.

18. Jack RJ31X provides a series connection to the tip and ring conductors of a telephone line. It is wired ahead of all station equipment electrically and is typically used with registered alarm reporting devices. When there is an alarm condition, the registered device functions to cut off all station equipment wired behind it, via this jack.

19. Jack RJ32X provides a series connection to the tip and ring conductors of a telephone line. It differs from RJ31X in that it is wired ahead of a particular telephone set rather than ahead of all the station equipment. It is typically used with registered automatic dialers.

20. Jack RJ33X is normally associated with a key telephone system. It provides a series connection to the tip and ring conductors of the telephone line and the key system line circuit A and A1 leads. The tip and ring conductors are wired ahead of the key system line circuit. This arrangement is typically used when the modem requires central office or PBX ringing.

21. Jack RJ34X is normally associated with a key telephone system. It is wired to provide a series connection to the key system line circuit tip and ring conductors and its A and A1 leads.

It differs from RJ33X in that all conductors are wired behind the key system line circuit. This arrangement is typically used when the modem is not critical as to type of ringing signal or does not require central office or PBX ringing.

22. Jack RJ35X is normally associated with a key telephone set. It is wired to provide a series connection to the tip and ring conductors of the telephone line and a bridged connection to the A and A1 leads. It differs from RJ33X and RJ34X in that the tip and ring leads are connected to the common wiring behind the pick-up keys of the station set but ahead of the switch hook. The jack is wired to the key telephone set so that the modem functions on the line selected on the key telephone set.

23. Jack RJ36X provides a connection for a registered telephone set equipped with an exclusion key when the telephone line is also to be used with a registered data set or registered protective circuitry. It is wired to provide a series connection to the tip and ring conductors of the telephone line and mode indication leads MI and MIC. With this jack, the exclusion key can be used to transfer the telephone line between the modem and the telephone set. As a customer option, the exclusion key may be wired so that either the telephone set or the modem controls the line. In the former case, the exclusion key must be operated to transfer the telephone line to the modem. In the latter case, the telephone line is normally associated with the modem. Operation of the exclusion key is required to transfer the line to the telephone set. In either case, a closure on the MI and MIC leads indicates the voice mode.

24. Jack RJ37X is used for providing two line service with exclusion. The jack is wired to provide a bridged connection to the tip and ring conductors of two telephone lines with exclusion on line 1.

25. Jack RJ38X provides a series connection to the tip and ring conductors of a telephone line identical to those described for RJ31X. However, the jack also provides a continuity circuit which is used as an indication that the plug of the registered equipment is engaged with the jack. The jack is wired ahead of all station equipment electrically and is typically used with registered alarm dialers.

26. RJ41S is a single line universal data jack normally associated with fixed loss loop (FLL) or programmed (P) modems. A switch, accessible to the user, is provided to select FLL to P type of operation. (FLL equipment transmits at -4 + 1 dB with respect to one milliwatt and a pad is included in the data jack so that pad loss plus loop loss is nominally 8 dB. Programmed modems adjust their output power in accordance with a programming resistor in the data jack. By these means, signals from either FLL or P types of registered modems will arrive at the local telephone company central office at a nominal -12 dB with respect to one milliwatt for optimum data transmission.) A sliding cover is provided to keep dirt and dust from entering the jack when it is not in use. The FLL/P switch selects the desired method of operation. Two matted surfaces are provided on the housing of the jack for the telephone company installer to write in the loop loss (designated LP L) and the telephone line number (designated T LN).

RJ45S is a single line data jack normally associated with programmed (P) modems. This jack is the same as the universal data jack RJ41S described above, except that the pad for fixed loss loop (FLL) equipment and the switch to select FLL or P type of operation are omitted. Its appearance is the same as RJ41S except that RJ45S does not have the FLL P switch.

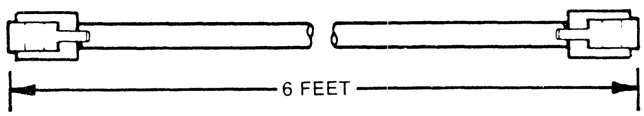
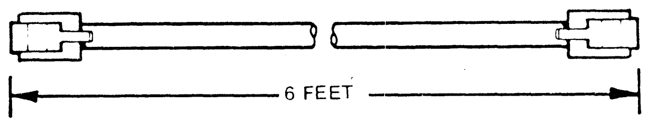
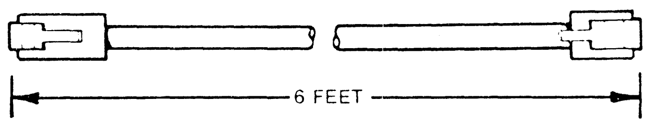
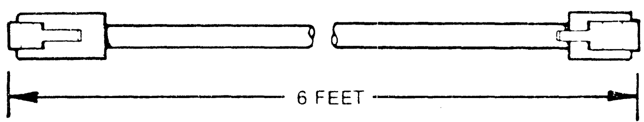
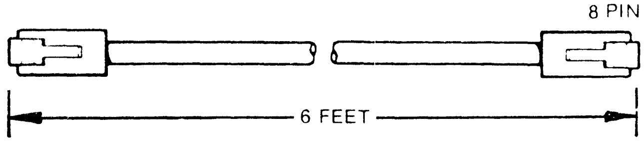
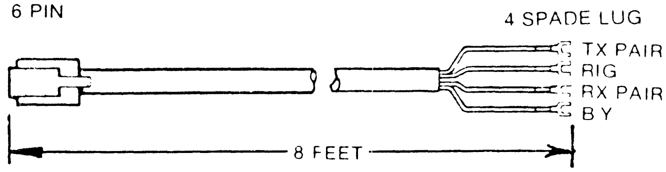
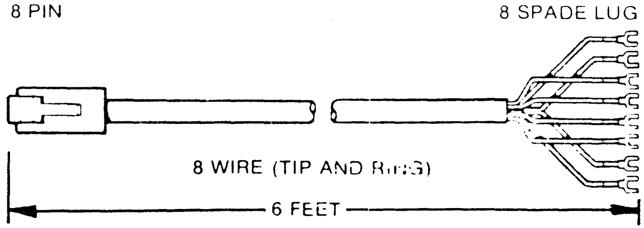
Both jacks provide bridged connections to the tip and ring of a telephone line and provide mode indication leads for use with exclusion key telephone sets when required. The exclusion key telephone set requires a series jack RJ36X as its normal means of connection.

The RJ41M and RJ45M provide a multiple mounting arrangement for mounting a number of RJ41S or RJ45S Single Line Universal or Programmed data jacks. The telephone companies will implement USOCs and RJ41M and RJ45M with RKM2X (which is the USOC for a mounting arrangement) and the appropriate number of RJ41S or RJ45S single line data jacks as required by the user. The mounting arrangement will accommodate up to 16 single line data jacks. In effect, this arrangement provides the features of a patch panel. The user has complete flexibility in patching the cord and plug from any modem to any line. The arrangement can be mounted on a wall or on 19 or 23 inch relay racks.

Appendix D

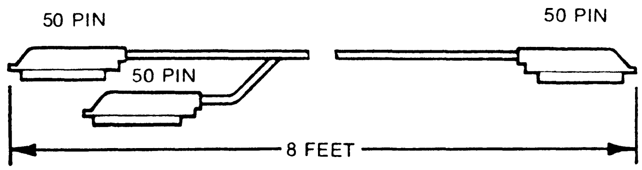
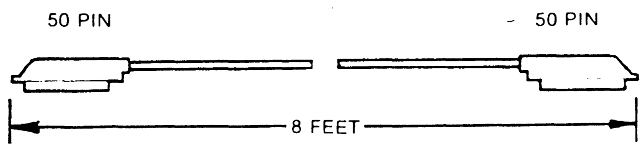
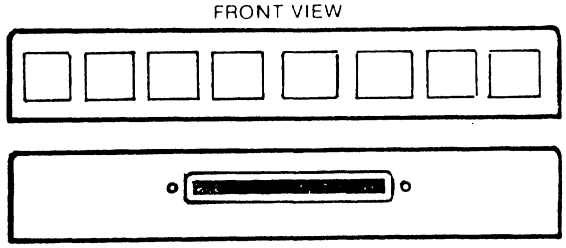
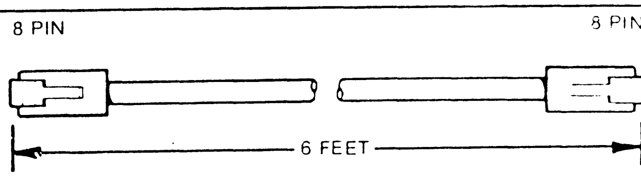
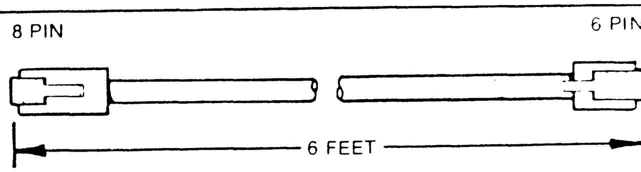
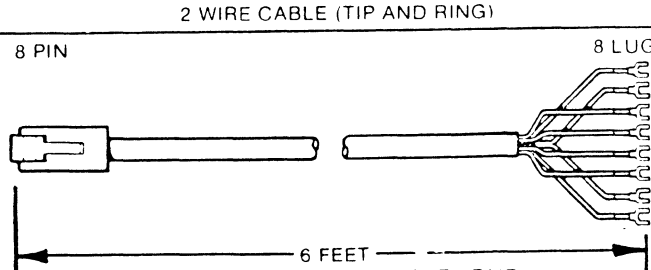
Standalone and Rack Mount Modem Cables

STANDALONE MODEM LINE

CABLE CODE	UDS PART NUMBER	MODEM CONNECTION	MECHANICAL LAYOUT	TELCO CONNECTION	TELCO JACK	USED ON
62	61020184	6 PIN	 6 FEET 2 WIRE CABLE (TIP AND RING)	6 PIN	RJ11C PERMISSIVE	ALL LP SERIES MODEMS.
64	61020410	6 PIN	 6 FEET 4 WIRE CABLE (TIP. RING. A AND A1)	6 PIN	RJ12C RJ13C PERMISSIVE	ALL LP SERIES MODEMS. (MULTIBUTTON PHONES)
68	61020202	8 PIN	 6 FEET 2 WIRE CABLE (TIP AND RING)	6 PIN	RJ11C PERMISSIVE	ALL DIRECT CONNECT STANDALONE MODEMS
59	61020418	8 PIN	 6 FEET 4 WIRE CABLE (TIP. RING. MI. MIC)	6 PIN	RJ16X PERMISSIVE	ALL DIRECT CONNECT STANDALONE MODEMS
66	61020192	8 PIN	 6 FEET 6 WIRE CABLE (TIP. RING. MI. MIC. PR. PC)	8 PIN	RJ45S PROGRAMMABLE RJ41S (PROGRAMMABLE ONLY)	ALL DIRECT CONNECT STANDALONE MODEMS
73	61020212	6 PIN	 TX PAIR RIG RX PAIR B Y 8 FEET 4 WIRE CABLE [TIP. RING (TX PAIR). TIP. RING (RX PAIR)]	4 SPADE LUG	PRIVATE LINE	ALL PRIVATE LINE MODEMS
82	61020232	8 PIN	 8 WIRE (TIP AND RING) 6 FEET	8 SPADE LUG	PRIVATE LINE 2 WIRE OPERATION	FOR 212A IN PRIVATE LINE MODE RED AND GREEN WIRES USED

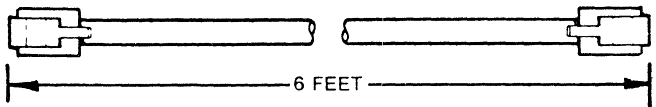
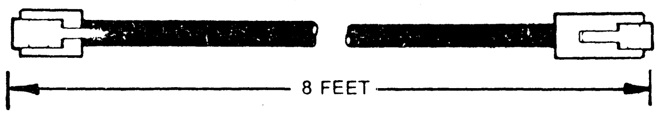
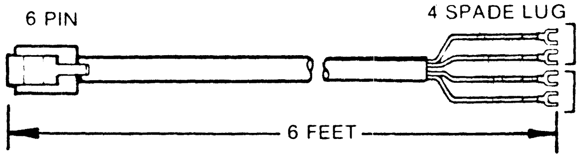
RACK MOUNT CABLES

RM16 D/C WITH 50 PIN BACKPLANE

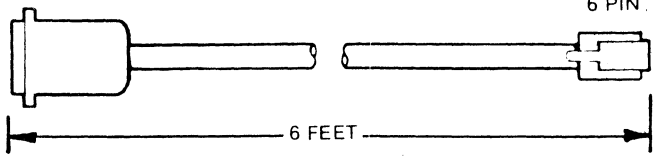
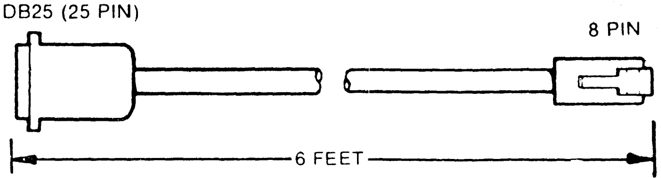
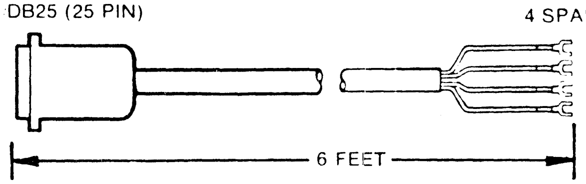
CABLE CODE	UDS PART NUMBER	RACK CONNECTION / MECHANICAL LAYOUT / TELCO CONNECTION	TELCO JACK	USED ON
63	61020181	 50 WIRE CABLE (MAX 16 PAIRS OF TIP AND RING)	RJ21X PERMISSIVE	RM16 D/C RACK MAX 16 LINES LESS IF AUTODIALERS ARE USED
61	61020171	 50 WIRE CABLE (MAX 8 PAIRS OF TIP & RING)	RJ27X PROGRAMMABLE	RM16 D/C RACK MAX 8 LINES PER CABLE. LESS IF AUTODIALERS ARE USED. 2 CABLES PER SHELF
NOT USED	61020240	FRONT VIEW  REAR VIEW	ADAPTER COVERTS 50 BACKPLANE CONNECTOR TO 8 (8 PIN) MODULAR CONNECTORS	2 ADAPTERS PER SHELF TO COVERT ALL 16 LINES PER PERMISSIVE/PROGRAMMABLE OR PRIVATE LINE
66	61020192	 6 WIRE CABLE (TIP RING, PR, PC)	RJ45S PROGRAMMABLE RJ41S (PROGRAMMABLE ONLY)	USED WITH ADAPTER PROVIDES PROGRAMMABLE CONNECTION EXCLUSION KEY PHONE CANNOT BE USED
68	61020202	 2 WIRE CABLE (TIP AND RING)	RJ11C PERMISSIVE	USED WITH ADAPTER PROVIDES PERMISSIVE CONNECTION EXCLUSION KEY PHONE CANNOT BE USED.
82	61020232	 8 WIRE CABLE [TIP AND RING (TX PAIR) RED AND GREEN] [TIP AND RING (RX PAIR) BROWN AND SLATE]	PRIVATE LINE 2 OR 4 WIRE	USED WITH ADAPTER PROVIDES PRIVATE LINE CONNECT. 4 WIRE OPERATION USE BOTH PAIRS. 2 WIRE OPERATION USE TX PAIR

RACK MOUNT CABLES CON'T.

RM16 D/C WITH 6 PIN MODULAR BACK PLANE

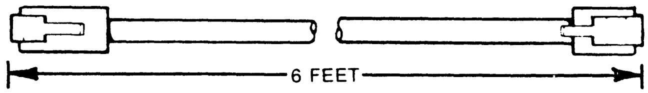
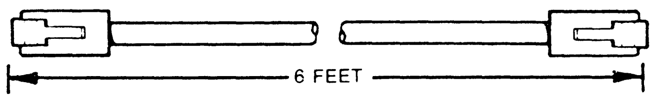
CABLE CODE	UDS PART NUMBER	RACK CONNECTION / MECHANICAL LAYOUT / TELCO CONNECTION	TELCO JACK	USED ON
62	61020184	6 PIN — 6 PIN  6 FEET 2 WIRES (TIP AND RING)	RJ11C PERMISSIVE	RM16 D/C RACK WITH MODULAR BACK PANEL MAX 16 SEPARATE LINES. LESS IF AUTODIALER USED
85	61020266	6 PIN — (BLACK CABLE) — 8 PIN  8 FEET 4 WIRES (TIP, RING, PROGRAM RESISTOR, PROGRAM COMMON)	RJ45S PROGRAMMABLE	RM16 D/C RACK WITH MODULAR BACK PANEL MAX 16 SEPARATE LINES LESS IF AUTODIALER USED
73	61020212	6 PIN — 4 SPADE LUG  TX PAIR R.G RX PAIR B.Y. 6 FEET 4 WIRE CABLE [TIP, RING (TY PAIR), TIP, RING (RX PAIR)]	PRIVATE LINE 2 OR 4 WIRE	RM16 D/C RACK WITH MODULAR CONNECTOR PRIVATE LINE CONNECTION 4 WIRE, USE BOTH PAIRS 2 WIRE, USE TX PAIR.

RM8 WITH STANDARD BACKPLANE. 25BP CONNECTORS

CABLE CODE	UDS PART NUMBER	RACK CONNECTION / MECHANICAL LAYOUT / TELCO CONNECTION	TELCO JACK	USED ON
60	61020166	DB25 (25 PIN) — 6 PIN  6 FEET 2 WIRES (TIP AND RING)	RJ11C PERMISSIVE	RM8 PACK
58	61020165	DB25 (25 PIN) — 8 PIN  6 FEET 6 WIRES, TIP, RING, MI, & MIC*, PR, PC)	RJ45S PROGRAMMABLE	RM8 PACK *RM8-208 MODEM ONLY HAS MI, MIC LEADS
#56	61020164	DB25 (25 PIN) — 4 SPADE LUG  R G] TY B W] RX 6 FEET 4 WIRES TIP, RING (TX PAIR) TIP RING (RX PAIR)	PRIVATE LINE	RM8 PACK

RACK MOUNT CABLES CON'T

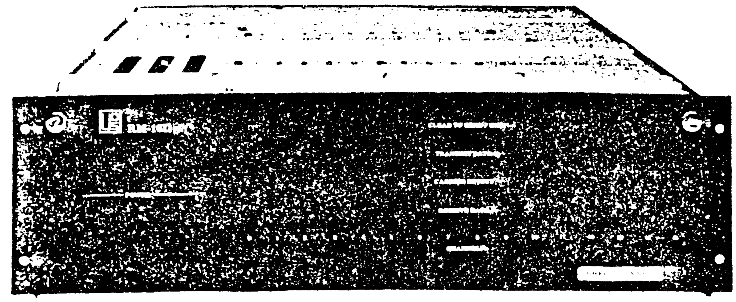
RM17 8 PIN MODULAR CONNECTOR PER MODEM

CABLE CODE	UDS PART NUMBER	MODEM CONNECTION	MECHANICAL LAYOUT	TELCO CONNECTION	TELCO JACK	USED ON
68	61020202	8 PIN	 6 FEET 2 WIRE CABLE (TIP AND RING)	6 PIN	RJ11C PERMISSIVE	ALL RM17 MODEMS
66	61020192	8 PIN	 6 FEET 6 WIRE CABLE (TIP, RING, PR, PC)	8 PIN	RJ45S PROGRAMMABLE RJ41S (PROGRAMMABLE ONLY)	ALL RM17 MODEMS EXCLUSION KEY PHONE CANNOT BE USED.

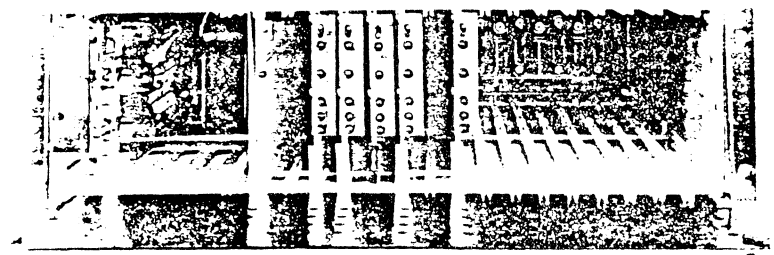
Appendix E

UDS RM8 and RM16 Racks

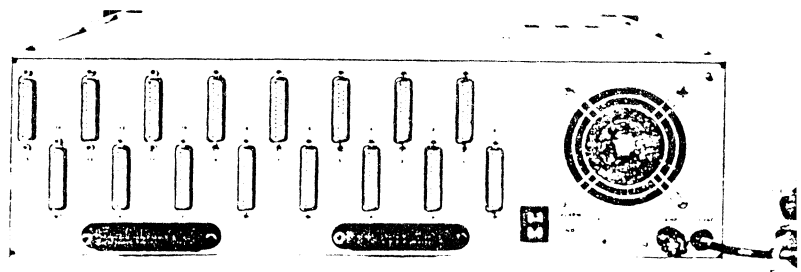
RM-16/RM-8 Racks



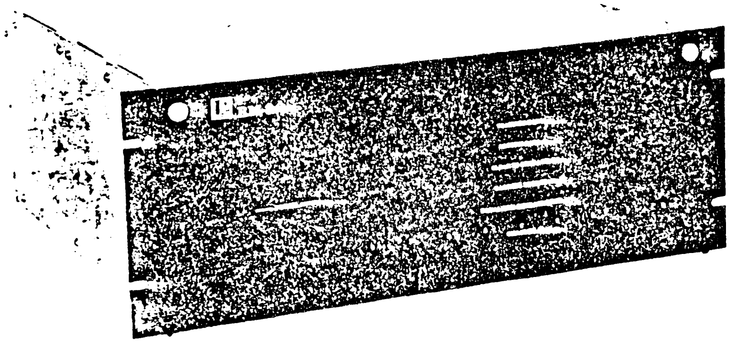
RM-16 DC
Front View



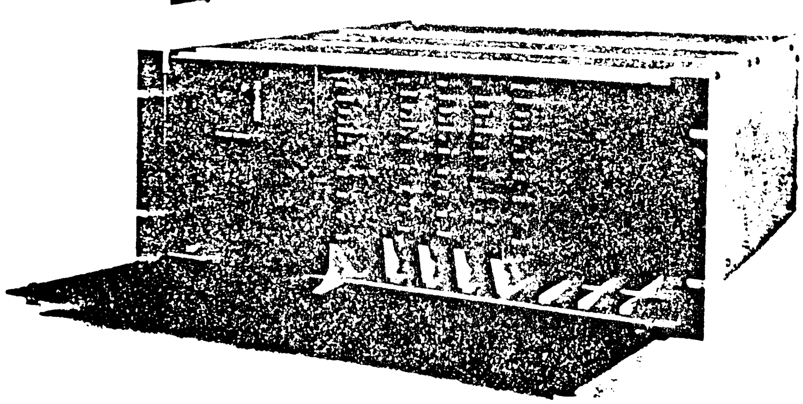
RM-16 DC
Front Panel
Lowered



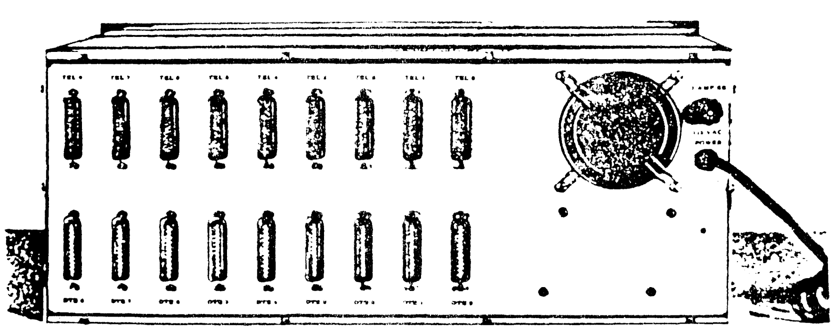
RM-16 DC
Rear View



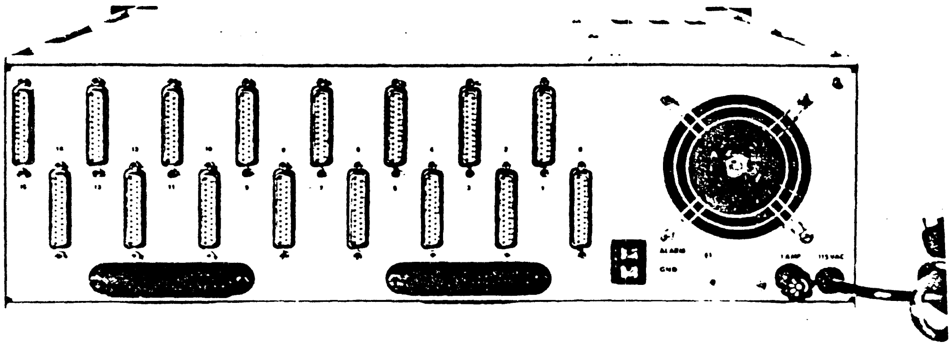
RM-8
Front View



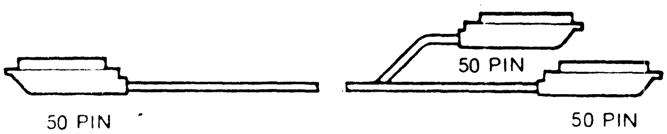
RM-8
Front Panel
Lowered



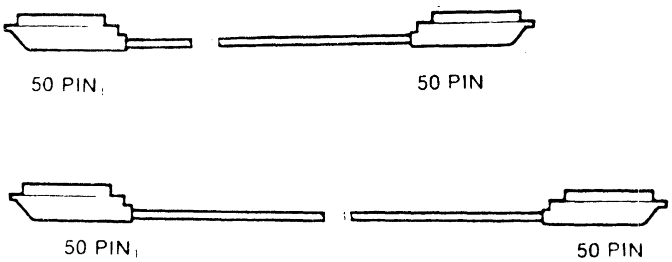
RM-8
Rear Panel



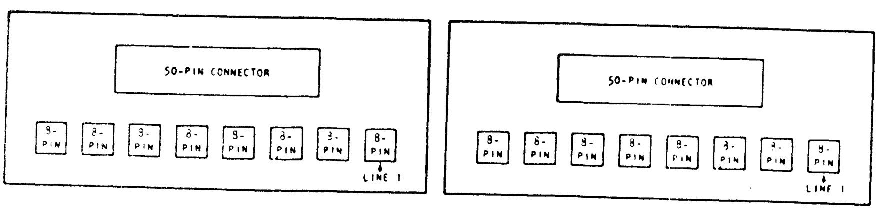
1. STANDARD
2. SPLIT
3. ALTERNATE



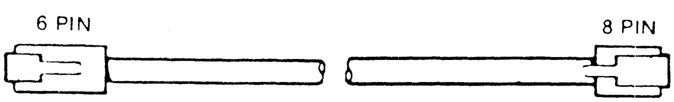
PERMISSIVE (RJ21X)
USE ONLY 16 OF 25 POSSIBLE
UDS PART NO. 61020181 CABLE CODE 63



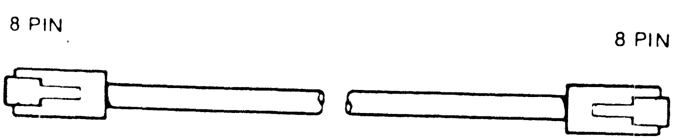
PROGRAMMABLE (RJ27X)
REQUIRES 2 CABLES
UDS PART NO. 61020171 CABLE CODE 61



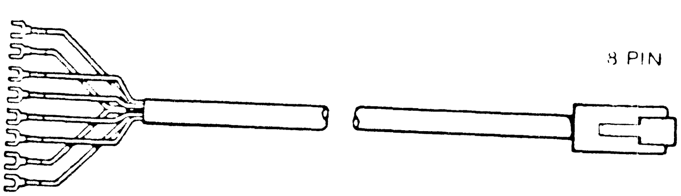
50 PIN TO 8 PIN MODULAR JACK
ADAPTOR BOARD



PERMISSIVE (VOICE JACK-RJ11)
UDS PART NO. 61020202 CABLE CODE 68

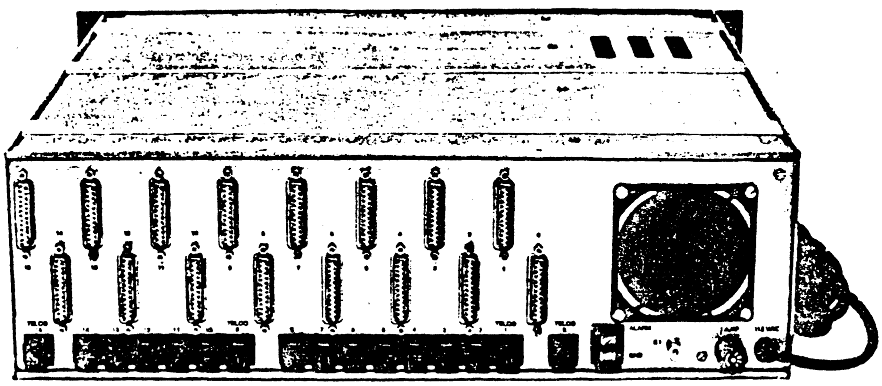


PROGRAMMABLE (DATA JACK-RJ45S)
UDS PART NO. 61020192 CABLE CODE 66

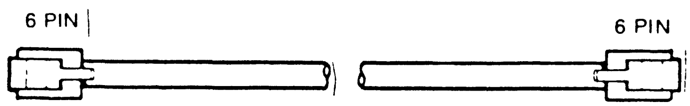


PRIVATE LINE
UDS PART NO. 61020232 CABLE CODE 82

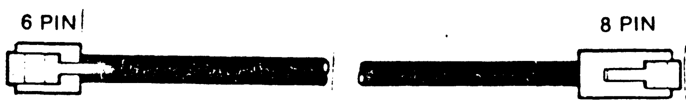
RM-16/DC TELCO CONNECTOR AND CABLE CONFIGURATION



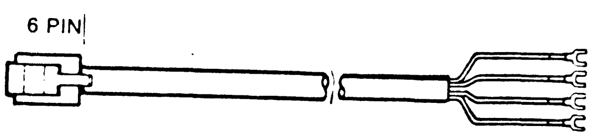
1. STANDARD
2. SPLIT
3. ALTERNATE



PERMISSIVE (VOICE JACK-RJ11C)
UDS PART NO. 61020184
CABLE CODE 62

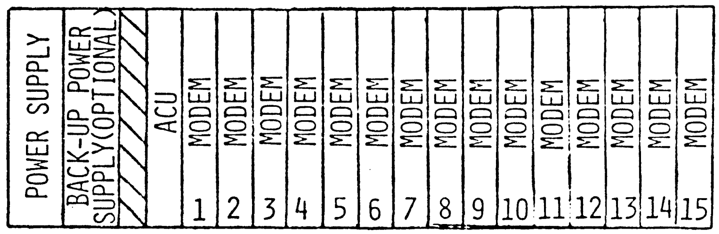


PROGRAMMABLE (DATA JACK-RJ45S)-
SPECIAL BLACK
UDS PART NO. 61020266
CABLE CODE 85



PRIVATE LINE
UDS PART NO. 61020212
CABLE CODE 73

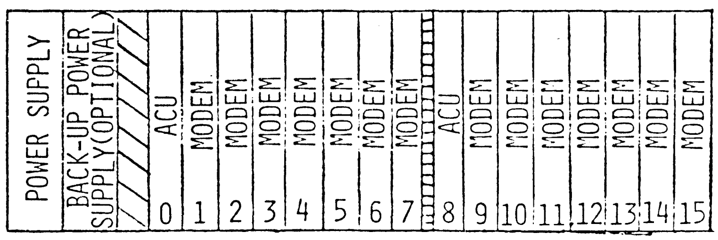
RM-16/DC TELCO CONNECTOR AND CABLE CONFIGURATIONS (CONT)



STANDARD BACKPLANE

50 PIN TELCO

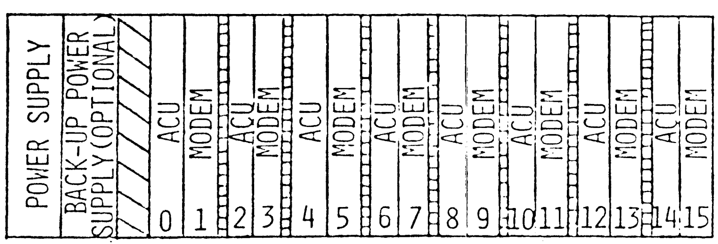
6 PIN MODULAR JACK



SPLIT BACKPLANE

50 PIN TELCO

6 PIN MODULAR JACK



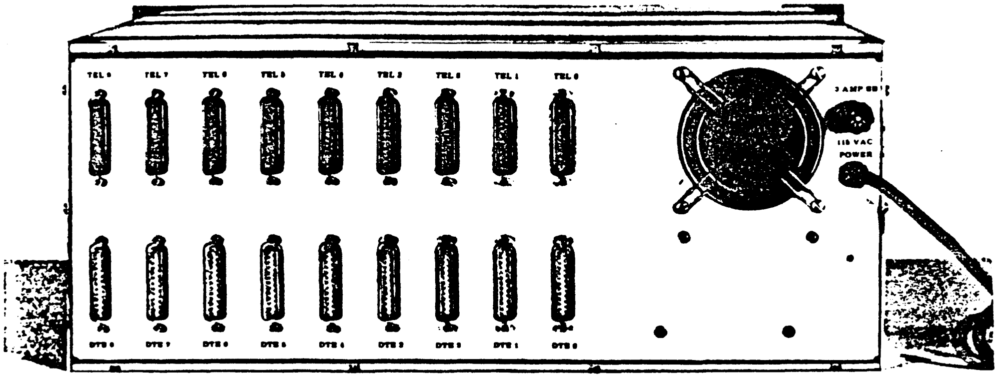
ALTERNATE BACKPLANE

50 PIN TELCO

6 PIN MODULAR JACK

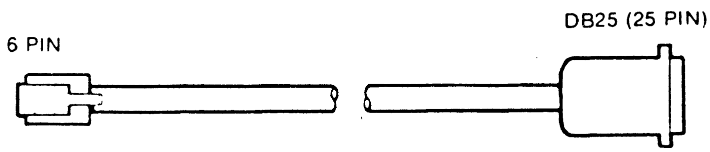
TYPES OF MODEMS...............	103, 108, 202S, 202T, 201B, 201C
TYPES OF ACU'S................	801A - PULSE WITH PARALLEL RS366
	801C - TOUCH TONE WITH PARALLEL RS366
	801AS - PULSE WITH SERIAL RS232
	801CS - TOUCH TONE WITH SERIAL RS232

RM-16/DC ACU/MODEM BACK PLANE CONFIGURATION

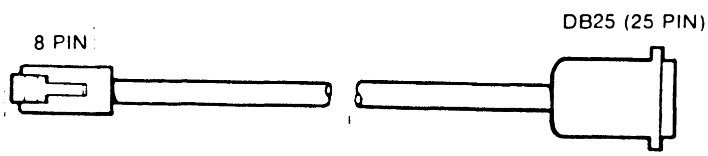


Female 25 Pin

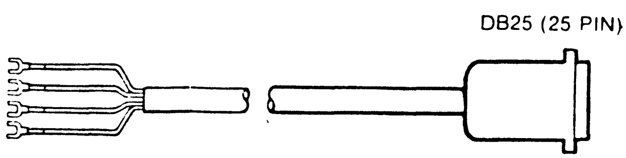
Male 25 Pin
Telco Connector



Permissive (Voice Jack-RJ11C)
UDS Part No. 610220166 Cable No.60

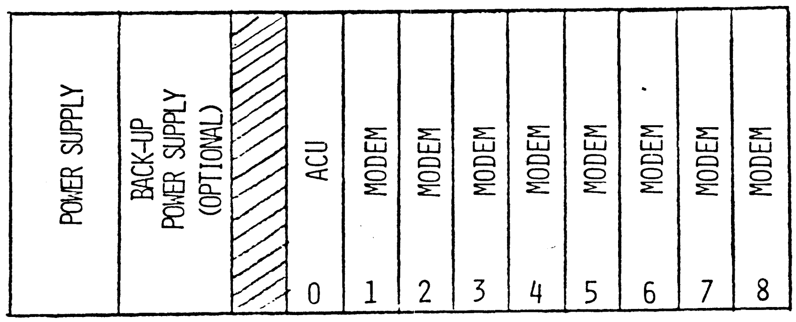


Programmable (Data Jack RJ45S)
UDS Part No. 61020165 Cable No.58

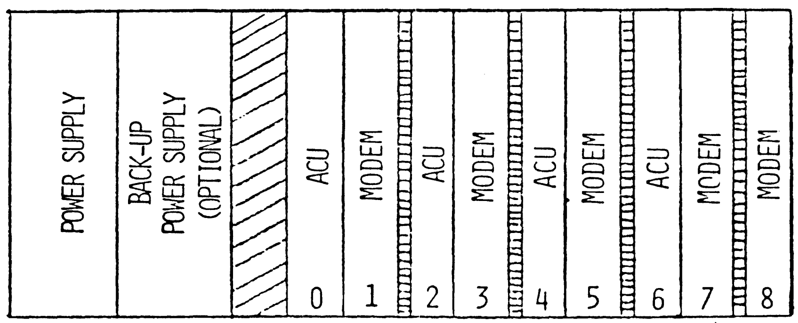


Private Line
UDS Part No. 61020164 Cable No.56

RM-8 Telco Connector and Cable Configurations



STANDARD BACKPLANE

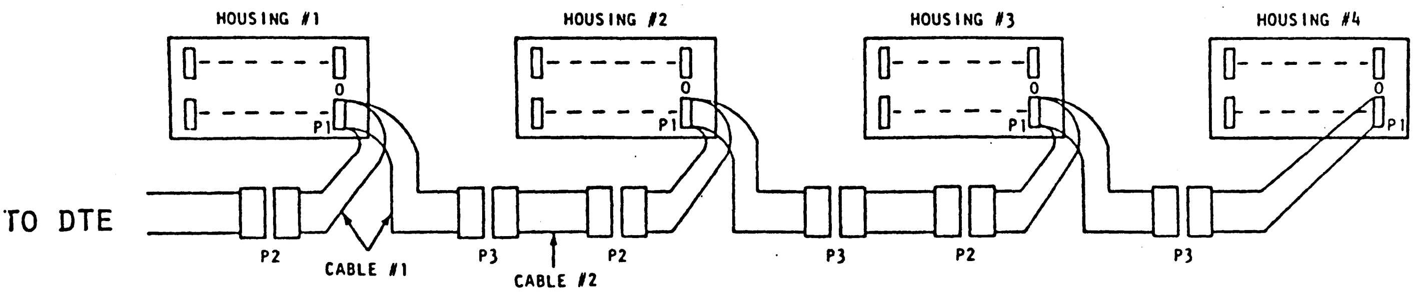


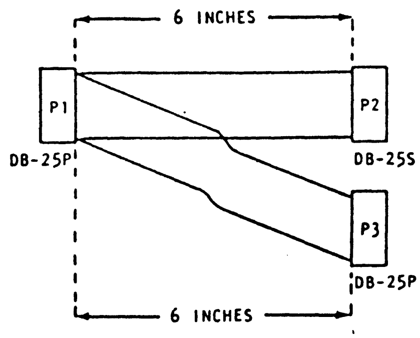
ALTERNATE BACKPLANE

TYPES OF MODEMS.............. 103, 108, 202S, 202T, 201B, 201C, 212A, 208A/B, 9600

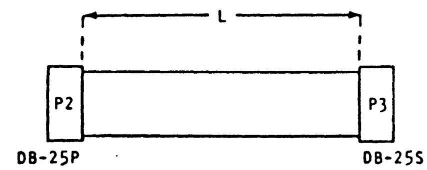
TYPES OF ACU'S............... 801A - PULSE WITH PARALLEL RS366
801C - TOUCH TONE WITH PARALLEL RS366
801AS - PULSE WITH SERIAL RS232
801CS - TOUCH TONE WITH SERIAL RS232

RM-8 ACU/MODEM BACK PLANE CONFIGURATION





CABLE #1



L = DESIRED LENGTH

CABLE #2

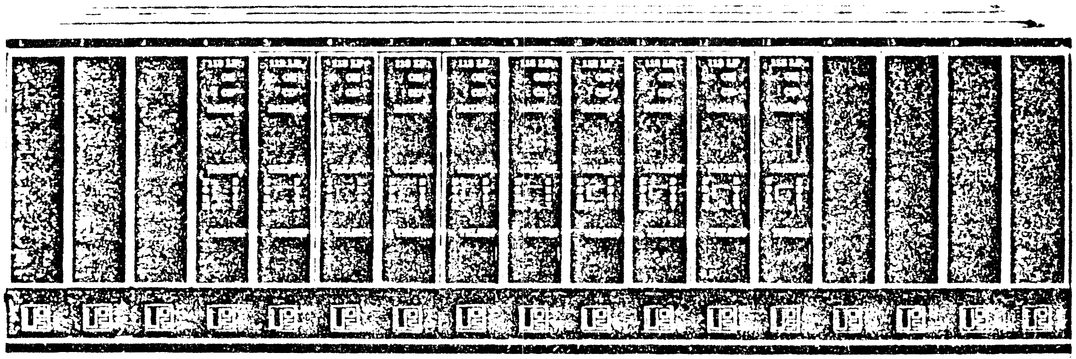
CABLE #2 IS WIRED PIN TO PIN FROM P1 TO P2
(I.E. 1 TO 1, 2 TO 2, ---,25 TO 25)

UDS PART NO. 1020205 SERIAL DIALING
CABLE CODE #71

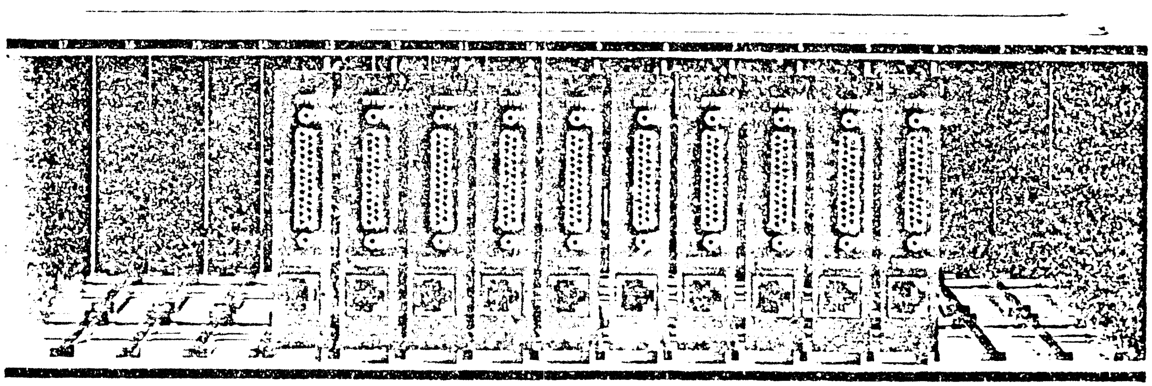
UDS PART NO. 1020203 PARALLEL DIALING
CABLE CODE #69

CABLE CODE #70
UDS PART NO. 1020204

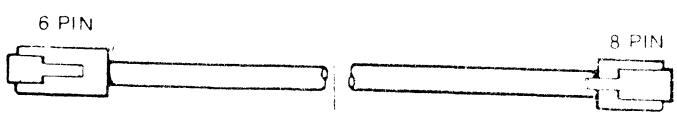
CASCADING DIALERS



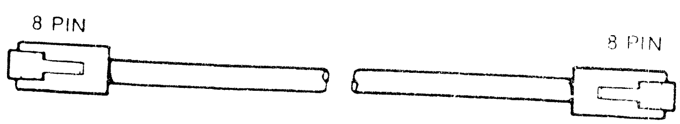
FRONT VIEW



REAR VIEW



PERMISSIVE (VOICE JACK-RJ11C)
UDS PART NO. 61020202
CABLE CODE 68



PROGRAMMABLE (DATA JACK-RJ45S)
UDS PART NO. 61020192
CABLE CODE 66

TYPES OF MODEMS........................ 113D, 202S
TYPES OF ACU........................... NONE
POWER SUPPLY........................... NONE (TELEPHONE LINE POWERED)

RM-17 RACK AND CABLE CONFIGURATIONS

Appendix F

Guidance in Selecting Custom OEM Modems

CD DATACOMM

GETTING THE MOST MODEM FOR THE LEAST MONEY

Today's relatively low modem costs can be cut further by defining specific data communications requirements and matching them to available modems, thus reducing the need for custom design.

John Jurenko Universal Data Systems, Incorporated
5000 Bradford Dr, Huntsville, AL 35805

Compared to the cost of central processing units and most peripheral devices, modems are relatively inexpensive. As distributed data processing grows in importance, however, systems engineers become increasingly sensitive to the cost of dozens or even hundreds of modems within a single system. One of the best ways to control modem cost is by stripping away everything that is not absolutely essential. Making the modem an integral part of a terminal, for example, eliminates the expensive housings, power supplies, controls, and switches that are required in a self-contained modem. The original equipment manufacturer modem, a board that can be plugged into a slot within the cabinet of a terminal or other system component, reduces this essential subsystem to its least costly configuration.

Modems are such a highly specialized part of a data communications system that many original equipment manufacturers (OEMs) purchase these subsystem elements from outside vendors. The technologies employed in modem design and manufacturing span a great many disciplines. Within the deceptively simple appearing boards, high speed streams of digital data are converted into audio signals; waveforms are precisely shaped, clipped, and buffered; the whole conversion process is performed in the opposite direction; and an immense variety of control and housekeeping functions are handled through a combination of hardwired and software techniques.

Signal handling is only part of a modem's job. Many systems also require the modem to handle diagnostic and testing chores and to give detailed indications of existing conditions within the modem itself, the associated terminal, the interconnecting network, and even the modem and terminal at the other end of the communication path. For high speed operation, modems incorporate automatic adaptive equalization that changes the filter characteristics with time as the transmission lines change. Finally, because they span the gap between a data processing system, with all of its peculiarities, and an interconnecting network, with its own rigid set of rules and peculiarities, modems can be viewed as devices that perform a combination of electronic, mechanical, and government agency mandated isolation functions.

CD DATACOMM

Considering all of the factors just mentioned, it is tempting to compile a very detailed list of specifications when seeking bids from modem vendors. In many cases, the tendency toward overspecification can lead to a much more expensive modem than the system actually requires. Temperature tolerances, for example, can be overstated to the point where an otherwise suitable off the shelf modem must be passed by in favor of a custom designed unit that uses specially selected components, incorporates additional circuitry, and requires expensive qualification testing. The cost of all this special work is worthwhile, of course, provided that the system truly needs the extra performance. However, most systems do not require much more than generally accepted performance within industry standard temperature ranges.

Throughout the modem industry, manufacturers suggest a high degree of vendor participation when it comes to specifying a custom modem for an OEM application. Their advice is to arrive at a general characterization of the modem performance level required and then to submit this outline information to selected vendors. Detailed specifications should be drawn up jointly with the vendors. This approach offers many benefits. There is a good chance of obtaining a recommendation for an off the shelf product that would cost less than a custom design. The final specification will be more meaningful than a specification generated by engineers who have limited modem experience. Costly overspecification can be avoided. Necessary details will be included that might

Modem Specification Outline

(Check Appropriate Boxes)

1. General System Information
   - ☐ Dial-up telephone network
   - ☐ Dedicated private line network
     - ☐ 2-wire
     - ☐ 4-wire
     - ☐ Point to point
     - ☐ Multidrop
   - ☐ Approvals and standards
     - ☐ FCC Part 68
     - ☐ Underwriters' Lab
     - ☐ CSA
     - ☐ PTT
     - ☐ Other ____________
2. Data Flow Information
   - Speed is____bits/s
   - ☐ Synchronous
   - ☐ Asynchronous
   - ☐ Full-duplex
   - ☐ Half-duplex
   - ☐ Simplex
   - ☐ Extreme data accuracy required
3. System Interface Information
   - ☐ Direct logic interface
     - ☐ TTL
     - ☐ CMOS
     - ☐ Other ____________
   - ☐ RS-232
   - ☐ MIL-188
   - ☐ EIA-449
   - ☐ IEEE-488
   - ☐ CCITT V.24
   - ☐ Other ______________
4. Terminal Power Available
   - ☐ OK to tap terminal
     - ±_____Vdc
     - ____mA
   - ☐ Dc to dc converter required
   - Modem must have independent power supply.
     - Power mains provide____V at____Hz.
5. Modem Circuit Board Requirements
   - ____±____in long
   - ____±____in wide
   - ____(max) in between cards (standard = 0.5 in)
   - operating temperature max (standard 50 °C)
6. Features and Options Desired
   - ☐ Analog loop test
   - ☐ Digital loop test
   - ☐ CCITT pseudorandom code generator
   - ☐ Error detect and display
   - ☐ Squelch
   - ☐ Multiple RTS-CTS delays
   - ☐ Auto dial
   - ☐ Auto answer
   - ☐ 2-wire 4-wire select
   - ☐ Originate only } Full-duplex modems only
   - ☐ Answer only }
   - ☐ Manual originate answer select
   - ☐ Automatic originate/answer select
   - ☐ External clock input
   - ☐ Output level select
   - ☐ Reverse channel
     - ☐ 5 bits/s
     - ☐ 75 bits/s
     - ☐ 150 bits/s
   - ☐ Disconnect options
     - ☐ a. 12-s absence of carrier
     - ☐ b. Loss of carrier
     - ☐ c. Loss of line current
     - ☐ d. Receive Long Space
     - ☐ e. Send Long Space
   - ☐ Busy out
   - ☐ Constant carrier
   - ☐ Carrier detect level
7. Purchasing Information
   - Need ________units this year
   - Need ________units next year
   - Need quote by________(Date)
   - Need evaluation prototype by ________(Date)
   - Need ________units per ________

CDX DATACOMM

otherwise be overlooked, especially in the area of telephone network interfacing. Helpful suggestions may result in testing and diagnostic features that cost less when incorporated into the modem subsystem than when included elsewhere in the overall product design. Finally, a written test procedure may be supplied if requested.

There are basic facts that any modem manufacturer must know in order to respond to a request for an OEM modem to be used in a product or system. If OEM modem customers would begin the purchasing process by preparing these facts, the entire relationship with vendors would be smoother, the process leading to a firm quotation would be easier, and far fewer problems would occur in the long run.

General System Application Information

Vendors need to know whether the system will be interconnected through the regular dial-up telephone network or through some type of leased line network. If the dial-up telephone network will be used, they must know whether this will involve Federal Communications Commission (FCC) registered, direct connect interfacing. Is the system (or any portion of it) destined for use in a foreign country? If so, which one? What sort of governmental agency approval might be required? (The FCC, Underwriters' Laboratories, CSA, and PTT, among others, should be considered.) If the system will be interconnected through a leased line network, is it a 2-wire system or a 4-wire system? Is it a point to point system, or is it a multidrop system with one transmission line connected to more than two stations? Are there any special engineering features that the modem vendor should know about? Will the system use any unusual data links, such as satellites or other long path carriers?

Specific Data Flow Information

Vendors also must know the required bit rate for digital data transmission. Modems are available to handle data speeds from fewer than 300 to 9600 bits/s. Special purpose modems can handle data at far higher rates; however, they are not compatible with the constraints encountered on conventional voice grade telephone lines. Will the system handle synchronous or asynchronous data? Will the terminals require full-duplex operation, or will half-duplex operation suffice? The required level of accuracy is another important data transmission parameter. For example, facsimile systems may be rather undemanding, while banking systems involving electronic transfer of funds cannot tolerate errors.

System Interfacing Information

What kind of interface is required? Available modems provide interface capability for use with several types of integrated circuits including transistor-transistor logic and complementary metal oxide semiconductor logic. Also available are so-called standard interfaces, such as EIA RS-232-C, MIL STD-188, IEEE-488, EIA RS-449, and CCITT V.24 and, if required, custom designed, bus oriented interfaces. In addition, another important piece of system information, the connector requirements, should be determined. How will other system elements connect to the modem? How will the modem plug into the network interconnection wiring?

Power Availability and Form Factor

Must the modem contain an independent power supply, or can operating voltages be taken from the associated terminal? If terminal power can be used, the available voltages and currents must be determined. How much space has been allotted to the modem? What are the dimensions of the cards used in the system? What is the separation between card slots? Where are the card connectors located, and what type of connector is being used? Must the modem occupy only a single card slot, or can it take up two or more slots? During actual system operation, will the modem card be in a vertical position or in a horizontal position? This last consideration can affect heat transfer and component cooling. Vendors also should know about any special environmental qualification that would require the modem to be constructed using a special printed circuit board material or specially qualified components.

Special Features and Options

Special features rank among the most difficult portions of the specification to anticipate. However, in this area, one can expect a great deal of prompting and assistance from the modem manufacturer. Are there any special testing needs? For example, analog or digital loop testing, built-in signal generators, and CCITT pseudorandom noise generators all are available, along with an almost infinite lineup of other diagnostic capabilities including automatic remote diagnosis, error detectors, quality monitoring subsystems, and so on. Additionally, such items as light emitting diodes that indicate functions generally used for testing (but not for signal handling) also can be specified. An example is a simple indicator that shows the presence of a carrier signal, a transmitted data signal, a received data signal, or any number of modem and terminal interface functions.

Options such as those described in some of the Bell standards should be considered. Does the modem require a squelch feature? Will the system employ only one delay between a request to send and a clear to send, or might several delay intervals be required? The list of possibilities in this category is a long one.

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Environmental Considerations

Normal environmental specifications for industry allow the equipment to operate within a temperature range of 0 to 50 °C. Relative humidity can be as high as 95% (without condensation). If the system must tolerate more extreme environments, the special component, construction, and testing requirements will have an especially significant impact on cost.

Purchasing Information

Of necessity, vendors require the best forecast of quantities needed and as much information as possible about the timing of deliveries. How closely can needs be synchronized with the modem vendor's normal cycle of product development, prototype testing, manufacturing release, volume production, and delivery? The earlier an agreement on these questions is reached, the more accurately actual costs will match initial cost estimates.

Proprietary Agreements

Assuming the required modem will be a custom designed product, the vendor should know whether a long term proprietary agreement will limit wider distribution or, alternatively, whether the design can be offered to other potential customers.

Custom Design Cost Considerations

Past relationships with other OEM subsystem vendors are a good guide in dealing with a modem manufacturer. Obviously, off the shelf, standard products are the least expensive to purchase, and this cost advantage remains valid when relatively minor modifications must be made to existing standard products. Using existing products to satisfy needs is a good business practice that benefits both parties.

If the product does call for custom design engineering, there will of course be a charge for the development effort involved. Typically, these charges are nominal and significantly lower than charges encountered in certain other segments of the electronics industry.

How to Get Started

Perhaps the best way to get started is by attempting to answer the questions presented here and in the Modem Specification Outline. Then, after organizing the data in some fashion, one or more modem manufacturers can be contacted by telephone. Allow the manufacturer to help decide whether an informal discussion among engineers might be of use before the specification is sent out for bids. An honest and helpful reply can be expected because the business advantages of volume production encourage modem manufacturers to exhaust all possibilities involving standard products before initiating a custom design project.

John Jurenko joined Universal Data Systems in 1975 as National Sales Manager, participating in the development of sales representatives and distributor programs, and was named Vice President of Sales in 1979. He has earned his BS and MS in electrical engineering.

Appendix G

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