# Primer on Premises Data Communications

by

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# *CHAPTER 1*

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## INTRODUCTION

Welcome to the subject of premises data communications. In this book we will explore its many facets, expose the various problems encountered in this area of interest and illustrate the way that these problems can be solved. The approach is very "results oriented." The view taken is not that of the academic network architect who has the opportunity and freedom of designing and specifying everything in advance by "starting with a blank page." Rather, for the most part, it is from the perspective of the person who has a premises data communications capability and for some reason or other is unhappy with it. It has problems which need to be dealt with. Either something needs to be fixed, expanded or protected. This book is a "Physician's Desk Reference" not a "Gray's Anatomy." Furthermore, we assume that our audience may or may not have a technical background in data communications. This book is written for the "hands on" user of data communication equipment, not the experienced design engineer.

It is best to begin by describing the setting for the communications problems of interest. Premises data communications deals with data communications in the office building, factory, manufacturing plant site or campus. An example of this environment, the small office building, is shown in Figure 1. The distances involved may vary from several inches to several thousands of feet. This is the world of what is commonly called short haul, limited distance or local area data communication. It is necessary to emphasize that this is not the world of long haul communication or Wide Area Networks-the world usually associated with long distance telephone dial-up circuits, leased lines, ISDN, packet switching, ATM or frame relay. Both data communication environments are important, but, the economics, technical problems and solutions differ.

Within the premises data communications setting there are data producing and using devices which need to be connected in order to support the modern automated office, factory or campus. These devices, these data sources and sinks, may be computers, computer terminals, badge readers, bar code readers, printers, plotters or other peripherals. These may even be the communication interfaces to the outside world, devices like high speed dial-up modems or packet switches.

The most commonly encountered situation in the premises data communications environment is that of the multi-user computer placed at one location e.g. the computer room, with terminals scattered throughout the rest of the building.

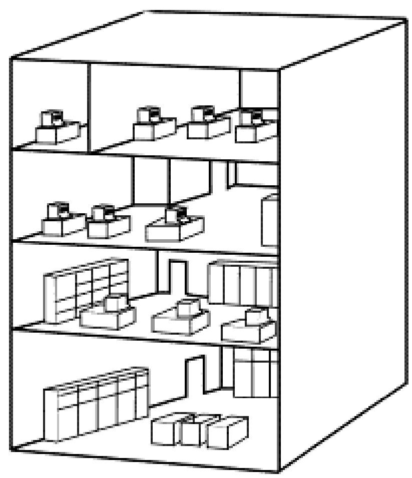


*Figure 1: Typical Premises Data Communications Environment*

In a sense from a user perspective it is a much "cozier" environment than that of the wide area network. The user can often "see," "touch" and play with all elements of the data communication system. The user has a closer connection to the data communication devices supporting the applications.

The subject of premises data communications deal with the methods and equipment needed to accomplish and support the connections of the data devices in this setting. While we said that our view is not "architectural" we must mention that there are three(3) architectural alternatives to solving this connection problem.

The first is the extreme of not really needing data communications at all due to the proliferation of self-contained work stations in the limited environment. All of the equipment needs of such a work station (both data processing and data communications) are contained within it and supplied by the same manufacturer or integrator. Here the problem of needing connection across the office building, factory or campus for the most part presents few challenges. We will touch upon these from time-to-time, but only in passing. The second alternative is that of accomplishing the connectivity through the use of a Local Area Network (LAN). Here all data equipment resources "tap onto" the LAN. True distributed computing, sharing of all data resources, is then possible. This is the approach of choice when one has the freedom and the money to design a system starting essentially with a "blank page." We will deal with this in some limited depth towards the end of this book in Chapter 8.

The third alternative is the central focus of our attention. Here premises data communications is accomplished across limited distances using an empirical approach. There is no "grand architectural" design. Rather, the needed capabilities evolve in a haphazard manner driven by the demand of an operating business to have something "up and running." Devices are connected in the most straightforward manner as they are purchased, dealing with problems as they arise, on a case by case basis. The premises data communications capability in this environment usually grows like "Topsy" in "Uncle Tom’s Cabin." It is driven by the need to service user connections of the type illustrated in Figure 2. Here we show terminals which need to be connected to a multi-user minicomputer or now a 286/386/486 PC running UNIX/XENIX with many users or some equivalent system.

The problems that are encountered come under a number of different headings: Equipment Interfaces, Wiring Alternatives, Extending Long Distance, Protection, Resource Sharing and Testing.

In the following chapters we will deal with these subjects. The most commonly encountered situations will be discussed. We will illustrate how the problems can be dealt with and when appropriate indicate which Telebyte products can be used as solutions.

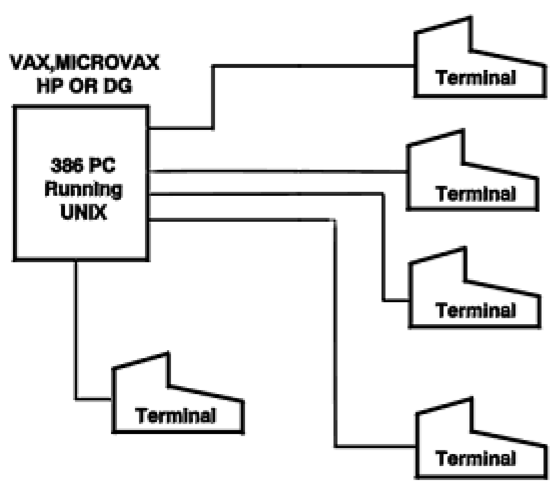



*Figure 2: Typical Multi-User PC Environment*

# CHAPTER 2

## INTERFACES

One of the most common problems encountered in premises data communications concerns the interfaces of the data equipments being connected. Of course, you may be totally oblivious even to the existence of interfaces. Many data communications users never think about them. Let’s get this out of the way right at the start and answer the simple query; What exactly is an interface?

Simpler yet is the response. An interface is just the point of connection on a data equipment unit. It is the location where data comes into and out of the equipment. Connecting two (2) different data equipment units together by their interfaces allows data and control information to be interchanged by them.

For such a simple definition interfaces provide considerable "meat" for discussion. Yet, this chapter should cover everything you need to know about them. This includes mechanical connectors, electrical signals, common problems and the area of interface conversion.

### 2.1 CONNECTORS

It will be worthwhile describing what interfaces look like from the physical-mechanical view. Take a look at the back of some data equipment unit, a terminal, a printer or a computer. You will see an interface. Unfortunately, we cannot say that this is a typical or a standard interface because, in fact, there is no such thing as a typical or a standard interface. However, in order to move our discussion along we can talk about the most common interfaces encountered.

The most ubiquitous physical interface is the DB25 Connector. This is a 25 pin, female connector which allows data and control signals to enter or exit a data equipment unit. Most other interfaces are also female. You will also find DB37, DB15, DB9, even larger rectangular 34 pin, female connectors. There are exceptions to this rule of generally having female connectors. First, there is the DEC world where you will find male connectors. Secondly, there is the world of the Personal Computer where the IBM PC AT and PC 386 both have 9 pin male connectors for the serial data communications port. Finally, certain equipment designers use modular phone connectors where there are three sizes; 4,6 or 8 pins.

### 2.2 SIGNALING TYPES

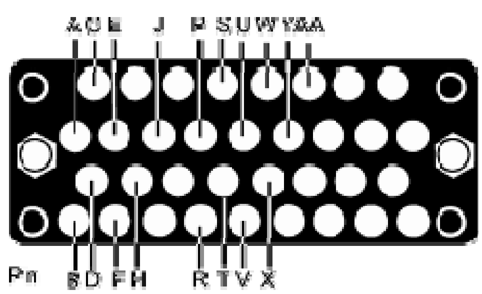
Equally important is to understand the electrical function of an interface. The voltages on the pins of an interface are used to represent both the data and control signals going into and out of the data equipment.

These signal voltages may either be single ended or differential. When single ended, they are measured with respect to a common ground in the interface. When differential, the voltages are generally differences between voltages that appear on two signal pins.

Voltages may also either be unipolar or bipolar. When unipolar, the voltage may be either a positive or negative relative to the ground. When bipolar, pin voltages will be either positive or negative depending on data. The most common interface is called EIA-232C (formerly RS-232C) or the European counterpart V.24. Many people still refer to "RS-232C" today even though this standard has been accepted and is officially "EIA-232C." Even at Telebyte we use "RS" and "EIA" interchangeably. This is the price for waiting so long to approve a recommended standard. Recently, EIA-232C has been "replaced" with EIA-232D. The differences between them are minor. The maximum distance for EIA-232C is specified as "50 feet." EIA-232D is specified by having a maximum cable capacitance of 2500 pF. This can be converted to a maximum length by dividing 2500 by the capacitance per foot of the EIA-232D cable.

"EIA" stands for "Electronic Industries Association" the principal data communications industry standards organization within the United States. "RS" stands for "Recommended Standard" of the EIA before formal adoption. "V" stands for the "fifth"section of the C.C.I.T.T. specifications. C.C.I.T.T. is the principal datacom industry standards organization in Europe. It is the initials of a French name which can be translated as Consulting Committee for International Telephony and Telegraphy.

In Figure 3 we show the mechanical layout and the pin definitions for interfaces which you may typically encounter. These include V.35, EIA-232C, Centronics and RS-449.

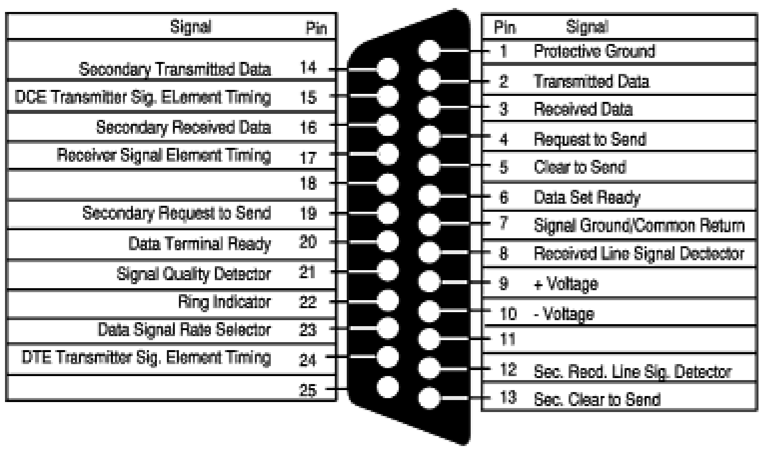



| Pin | Signal | Pin | Signal |
|---|---|---|---|
| A | Chassis Ground | B | Signal Ground |
| C | Request to Send | D | Clear to Send |
| E | Data Set Ready | F | Receive Line Signal Detect |
| H | Data Terminal Ready | J | Ring Indicator |
| P | Transmitted Data (Signal A) | R | Recieved Data (Signal A) |
| S | Transmitted Data (Signal B) | T | Received Data (Signal B) |
| U | Terminal Timing | V | Receive Timing A |
| W | Terminal Timing | X | Receive Timing |
| Y | Transmit Timing | AA | Transmit Timing |

*Figure 3a: V.35 Interface*

Besides these interfaces you may come across others in dealing with your premises data communications problems. EIA-232 has an upper data rate limit of 19.2 KBaud. EIA-530 is a signal assignment which supports data rates above this but using the same mechanical specifications (connector). If you are dealing with data equipment in a military environment you may encounter "flavors" of the MIL-STD-188 interface (i.e. 188C, 188-114 Type 1,188-114 Type 2). These closely parallel EIA-232 but with a few deviations such as inverted logic for data signals and +/- 6 Volts for data control. Grocery stores with bar code readers at cash registers and building security systems with badge readers and intrusion detection devices may use polling systems employing the RS-485 interfaces.

If you would like to learn about the detail of these (and other) interface standards order a copy of Telebyte’s "Data Communications Standards Library." Its a worthwhile reference and costs only $ 49.95.



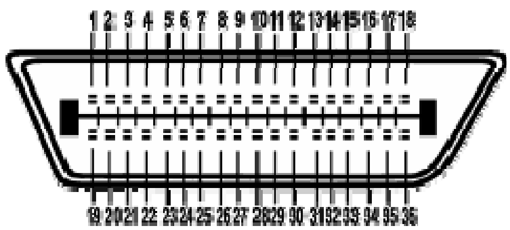

| Pin | EIA CKT | Description | From DCE | From DTE |
|---|---|---|---|---|
| 1 | AA | Protective Ground | | |
| 2 | BA | Transmitted Data | | *D |
| 3 | BB | Received Data | *D | |
| 4 | CA | Request to Send | | *C |
| 5 | CB | Clear to Send | *C | |
| 6 | CC | Data Set Ready | *C | |
| 7 | AB | Signal Gnd/Common Return | | |
| 8 | CF | Rcvd. Line Signal Detector | *C | |
| 12 | SCF | Secondary Rcvd. Line Sig. Detector | *C | |
| 13 | SCB | Secondary Clear to Send | *C | |
| 14 | SBA | Secondary Transmitted Data | | *D |
| 15 | DB | Transmitter Sig. Element Timing | *T | |
| 16 | SBB | Secondary Received Data | *D | |
| 17 | DD | Receiver Sig. Element Timing | *T | |
| 19 | SCA | Secondary Request to Send | | *C |

| | | | | |
|---|---|---|---|---|
| 20 | CD | Data Terminal Ready | | *C |
| 21 | CG | Sig. Quality Detector | *C | |
| 22 | CE | Ring Indicator | *C | |
| 23 | CI | Data Sig. Rate Selector (DCE) | *C | |
| 23 | DA | Transmitter Sig. Element Timing | | *T |

Signal Type: D=Data, C=Control, T=Timing

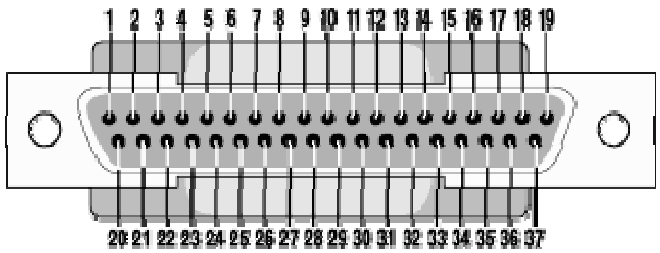
Note: On the DB25 connector that is commonly used for RS232:
Pins 9 and 10 are reserved for Data Set Testing.
Pins 11, 18 and 25 are undefined.
Pin 23 may be defined as CI or CH.

*Figure 3b: Interface Specification for EIA-232C*



| Pin | Signal | Pin | Signal |
|---|---|---|---|
| 1 | Data Strobe | 19 | (R) Data Strobe |
| 2 | Data Bit 1 | 20 | (R) Data Bit 1 |
| 3 | Data Bit 2 | 21 | (R) Data Bit 2 |
| 4 | Data Bit 3 | 22 | (R) Data Bit 3 |
| 5 | Data Bit 4 | 23 | (R) Data Bit 4 |
| 6 | Data Bit 5 | 24 | (R) Data Bit 5 |
| 7 | Data Bit 6 | 25 | (R) Data Bit 6 |
| 8 | Data Bit 7 | 26 | (R) Data Bit 7 |
| 9 | Data Bit 8 | 27 | (R) Data Bit 8 |
| 10 | Acknowledge | 28 | (R) Acknowledge |
| 11 | Busy | 29 | (R) Busy |
| 12 | Paper End | 30 | (R) Paper End |
| 13 | Select | 31 | Input Prime |
| 14 | Supply Ground | 32 | Fault |
| 15 | OSCXT | 33 | Undefined |
| 16 | Logic Ground | 34 | Undefined |
| 17 | Chasis Ground | 35 | Undefined |
| 18 | +5V | 36 | Undefined |

*Figure 3c: Specification for Parallel Interface (Centronics)*




| Pin A | Pin B | EIA CKT | Description | From DCE | To DCE |
|---|---|---|---|---|---|
| 1 | | | Shield | | |
| 2 | | SI | Signaling Rate Indicator | *C | |
| 4 | 22 | SD | Send Data | | *D |
| 5 | 23 | ST | Send Timing | *T | |
| 6 | 24 | RD | Receive Data | *D | |
| 7 | 25 | RS | Request to Send | | *C |
| 8 | 26 | RT | Receive Timing | | |
| 9 | 27 | CS | Clear to Send | *T | *C |
| 10 | | LL | Local Loopback | | *C |
| 11 | 29 | DM | Data Mode | *C | |
| 12 | 30 | TR | Terminal Ready | | *C |
| 13 | 31 | RR | Receiver Ready | *C | |
| 14 | | RL | Remote Loopback | | *C |
| 15 | | IC | Incoming Call | *C | |
| 16 | | SR | Signaling Rate Selector | | *C |
| 17 | 35 | TT | Incoming Call | | *T |
| 18 | | TM | Test Mode | *C | |
| 19 | | SG | Signal Ground | | |
| 20 | | RC | Receive Common | | |
| 28 | | IS | Terminal in Service | | *C |
| 32 | | SS | Select Standby | | *C |
| 33 | | SQ | Signal Quality | *C | |
| 34 | | NS | New Signal | *C | |
| 36 | | SB | Standby Indicator | | *C |
| 37 | | SC | Send Common | | |

Signal Type: D = Data, C = Control, T = Timing
Note: On the DB37 connector that is commonly used for RS449; Pins 3 and 21 are undfined
B = Return

*Figure 3d: Interface Specification for RS-449*

Cables are used to connect the interface of one data equipment unit to another. But even the simple problem of cable connection presents situations of which you should be aware. For example, consider the need to connect a computer to a printer with the computer having a female interface and the printer having a female interface. In order to accomplish the connection you would need a cable with male connectors at both ends and consistent with both the computer and printer interfaces.

## 2.3 EVERY DAY PROBLEMS WITH INTERFACES

The typical premises data communication user is always encountering operational problems related to interfaces.

These problems are grouped as: 1) identity, 2) gender, 3) distance, 4) interface conversion and 5) media conversion.

### 2.3.1 IDENTITY

To discuss the identity problem it will be worthwhile to introduce some nomenclature. Data processing equipment is usually referred to as data terminal equipment and abbreviated DTE. These equipments such as terminals, computers and printers are considered as a class separate from equipment used to transport or communicate data such as modems, line drivers and multiplexers. Such communication equipment is referred to as data communications equipment and abbreviated DCE. Whether or not an equipment unit is a DTE or a DCE has significance with regards to the interface. Interfaces are usually defined assuming that the equipment of which the interface is the debarkation point is in fact a DTE.

A typical misconception is that the pin of the interface labeled Transmit Data (TD) implicitly assumes that the equipment of which it is part is a DTE. Along with this the interface is defined assuming that the data coming out of the TD pin is supposed to go into a data communication equipment unit, a DCE. The interfaces of a DTE and DCE must mate consistent with this assumption. The TD pin of a DTE interface must mate with the TD pin of the DCE interface.

However, what happens if you want to connect not a DTE and a DCE but two DTE’s? If you think this is a rare possibility then think again. Actually, it is quite a common situation. It occurs when you want to connect a computer and a printer. Now show me the facility where someone does not need a computer and a printer linked. The computer outputs data on the TD pin, Pin 2, of its interface. However, if a one-to-one cable is used a printer’s receive data pin, RD, Pin3, can not be mated properly to capture this data. No need to worry. This problem can be solved quite easily. Just use a passive modem eliminator in order, effectively, to change the wiring between the pins of the interface so that the computer’s TD pin mates with the printer’s RD pin. The device is called a modem eliminator because, historically, people used a "Rube Goldberg" approach to deal with this problem. They inserted DCE types of devices between the two DTE devices needing to be connected in order to get the consistent mating of their plugs. That is, in the early days of premises data communications users set up a system where the connector went from the computer to a modem which was connected back-to-back to another modem and then to a printer. This approach is illustrated in Figure 4.

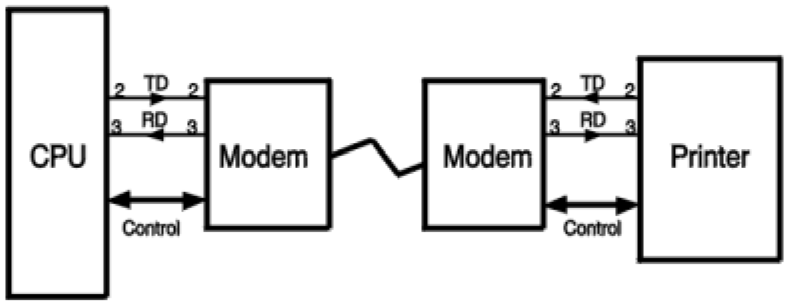



*Figure 4: Early Solution to Unscramble Interfaces*

This haphazard approach did accomplish the proper mating of the pins. Of course, with this you were using the modem in a very uneconomic, costwise ineffective, manner. It was being used just to solve an interface problem and not being used for what it was designed, for extending the distance - one of the other subjects that we are going to be discussing. Much of the internal electronics of the modem was just being wasted The modem eliminator shown in Figure 5 is a device which effects the pin conversion but without the complexity and cost of the modem's signaling capacity.

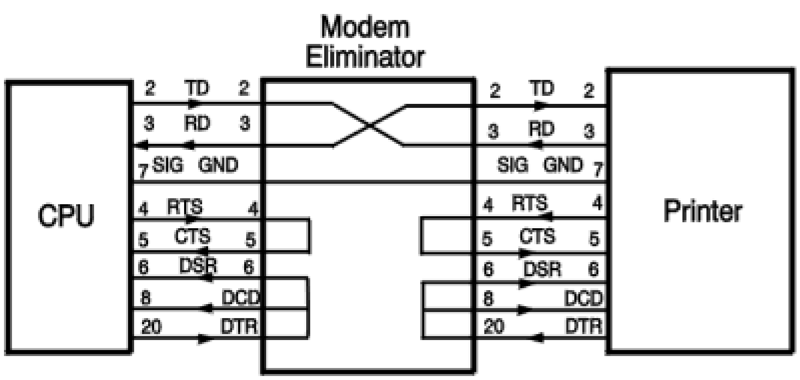



*Figure 5: Present Modem Eliminator*

#### 2.3.2 GENDER

Gender mending sounds exotic but is really quite easy to describe. We have talked about the interfaces, possibly being female or male. Yet, what happens when one wants to connect equipment units directly together where both units only have male connectors?

To deal with this problem you can either use a connecting cable with a female interface connector at each end or you can use a device called a gender mender which is sometimes called a sex changer. This small device plugs into the interface on one of the equipment units and changes gender, either from male to female or female to male, to be consistent with the sex of the interface on the other equipment unit. You can use two connecting cables with the same gender connector on both ends. A low profile, gender changer is shown in Figure 6.

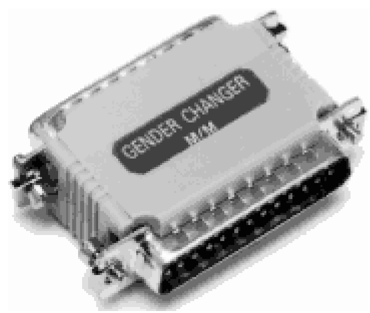



*Figure 6: Low Profile Gender Changer*

#### 2.3.3 DISTANCE

There is always concern with extending the distance between two data equipment units that you are trying to connect by joining their interfaces together with a cable. The various interface standards shown in Figure 3, as well as any other interface standard, are usually defined for signalling at a known rate at a specific distance between the two data equipment units to be connected. That is, the voltage levels on the various pins are guaranteed to interchange data and control signals reliably, provided that the cable interconnecting the two interfaces together is no more than a certain length. As mentioned previously, for the EIA-232C interface, this distance can be at most 50 feet at 9600 Baud. The distance specifications for common interfaces are provided in Table 1.

| Distance and Data Rate Specifications for Typically Encountered Interfaces | |
|---|---|
| EIA-232C | 50 feet at 9600 Baud |
| RS-422 | 1,000 feet at 256 KBaud<br>6,000 feet at 19.2 KBaud<br>18,000 feet at 9.6 KBaud<br>All full duplex |
| RS-485 | No actual distance/data rate specification<br>Usually quoted same as RS-422 but half duplex |
| V.35 | Data rate in excess of 56 KBaud<br>Distance usually quoted same as RS-422 |

***Table 1***

Of course, users need to be concerned when the data equipment units being interconnected are separated by more than the maximum allowed distance.

In order to connect the units together and effect reliable interchange you must use either a special extender cable or resort to signal boosting devices such as line drivers (also called short haul modems or limited distance modems). More will be said about these devices in a later Chapter 4.

#### 2.3.4 INTERFACE CONVERSION

Here the concern with interfaces involves the interconnection of two equipment units that need to be connected but have two different interfaces. For example, one might want to connect a computer to a printer with the computer having an EIA-232C interface while the printer has a Current Loop interface. The problem of interconnecting the equipment where the interfaces are different is quite complex and presents a number of different solutions.

First, you must determine the minimum number of signals needed for the two devices to communicate. Obviously, TD and RD (transmit and receive data) must be interconnected through the interfaces but many of the control signals which come from the various pins of the interfaces may not be needed. You need to look at the details of the equipment documentation and determine the minimum number of control signals to be transferred. To bring this point into sharpest relief most data equipment users don't realize that, if they can use the X-ON/X-OFF protocol they only need pins 2, 3 and 7 of the EIA-232 connector, all other pins are extraneous.

Once the minimum number of signals is determined you must find an interface converter that accomplishes the necessary end conversion and verify that it has the capability to satisfy this transfer of the minimum number of control signals. Obviously there is a trade off in the cost of the interface converter between the number of signals it can transfer and its cost.

Always physically locate the converter so as to get the maximum benefit from the interface which has the ability to transmit signals over the greater distance. For example, in connecting an RS-232C based DTE to an RS-485 based DTE the conversion should be done as close as possible to the EIA-232C device so as to get the greater distance benefit of RS-485.

Table 2 illustrates the wide variety of interface converters available from Telebyte.

**Interface Converter Selection Guide**

| Model | Interface 1 | | Interface 2 | | No. of Signals Converted | Physical | Remarks | Price |
|---|---|---|---|---|---|---|---|---|
| | Type | Conn. | Type | Conn. | | | | |
| 62-1/2 | RS-232 | DB25 | EIA-530 | DB25 | 13 | SA | RS-422 Signals | $140 |
| 63-2SA | RS-232 | DB25 | RS-422 | Term | 2 | SA | TD & RD LED's | $99 |
| 63-3/4 | RS-232 | DB25 | RS-422 | DB25 | 8 | SA | Very Popular | $130 |
| 65AX | RS-232 | DB25 | CLOOP* | TERM | 2 | SA | Active or Passive | $99 |
| 121 | RS-232 | CARD | RS-422 | TERM | 2 | RM | Dual Converters | $150 |
| 122 | RS-232 | CARD | 422/485 | TERM | 4 | RM | Dual Converters | $195 |
| 234 | RS-232 | DB25 | RS-232 | DB25F | 9 | SA | Modem Eliminator | $185 |
| 235 | V.35 | 34 Pin F | V.35 | 34 Pin F | 7 | SA | Modem Eliminator | $490 |
| 236 | G.703 | RJ-45 | V.35/RS-232 | DB25 | 4 | SA | 64 KBPS G.703 | $410 |
| 240 | RS-232 | DB25 | V.35 | DB25F | 13 | SA | DTE/DCE & LCD | $220 |
| 242 | RS-232 | DB25 | X.21 | DB15 | 5 | SA | Power Stealing | $148 |
| 243 | RS-232 | DB25 | X.21 | DB15 | 5 | SA | DTE/DCE & LCD | $245 |
| 245 | RS-232 | DB25 | 422/485 | DB25 | 2 | SA | Opto-Isolated | $226 |
| 248 | V.35 | DB25 | V.35/232 | DB25 | 10 | SA | Opto-Isolated | $295 |
| 253 | RS-232 | DB9 | RS-422 | TERM | 2 | SA | Power Stealing | $84 |
| 256 | RS-232 | DB25 | RS-422 | RJ11/TERM | 2 | SA | TD Powered/LCD | $95 |
| 260 | RS-232 | DB25 | RS-422 | TERM | 2 | SA | Power Stealing | $96 |
| 261 | RS-232 | DB25 | RS-422 | DB25 | 2 | SA | DG Compatible | $82 |
| 263 | RS-232 | DB25 | RS-422 | TERM | 2 | SA | Power Stealing | $70 |
| 265 | RS-232 | DB25 | RS-422 | TERM | 2 | SA | TD Powered | $142 |
| 267-12 | RS-232 | DB25 | EIA530 | DB25** | 13 | RM | 10CATI,3 CAT II | $209 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 267-34 | RS-232 | DB25 | 188-14 | DB25 | 13 | RM | MIL-STD-188-115-TYPE1 | $309 |
| 268 | RS-232 | DB25 | RS-232 | DB25 | 4 | SA | Opto-Isolated | $106 |
| 272 | RS-422 | DB25 | Fiber | ST | 2 | SA | Full Duplex | $152 |
| 276 | RS-485 | DB25 | Fiber | ST | 2 | SA | Half Duplex | $152 |
| 279 | Fiber | Multimode | Fiber | Singlemode | 2 | SA | DC-2.5 MBPS | $775 |
| 281 | RS-422 | DB25 | RS-422 | DB25 | 4 | SA | Opto-Isolated | $158 |
| 282 | RS-232 | DB25 | RS-232 | DB25 | 8 | SA | Opto-Isolated | $195 |
| 284 | PC BUS | CARD | RS-422 | DB25 | 10 | CARD | Supports IBM PC | $166 |
| 285 | RS-232 | DB25 | RS-422/485 | TERM | 2 | SA | Select 422 or 485 | $135 |
| 287 | RS-232 | DB9 | RS-422 | RJ-12 | 2 | SA | 4 KV Isolation | $155 |
| 290 | RS-232 | DB25 | 422/485 | RJ-11 | 2 | SA | 16 422/485 | $695 |
| 365 | RS-232 | DB25 | RS-422/485 | --- | 2 | SA | AC Powered | $148 |
| 366 | RS-232 | DB25 | RS-485 | TERM | 2 | SA | AC Powered | $115 |
| 370 | AUI | DB15 | Fiber | ST | 2 | SA | Powered by AUI | $220 |
| 371 | 10Base-T | RJ-45 | Fiber | ST | 3 | SA | AC Powered | $290 |
| 372 | 100Base-T | RJ-45 | Fiber | ST | 2 | SA | AC Powered | $349 |
| 373 | 10Base-T | RJ-45 | Fiber | ST | 2 | SA | 10 Base FL compatible | $290 |
| 374 | 10Base-T | RJ-45 | Fiber | Singlemode | 2 | SA | 10 Base FL compatible | $649 |
| 8321 | RS-485 | Term | RS-485 | Term | 2 | DIN | Opto Isolated | $279 |
| 8322 | RS-232 | Term | RS-485 | Term | 2 | DIN | Opto Isolated | $270 |
| 8323 | RS-232 | Term | RS-422 | Term | 2 | DIN | Opto Isolated | $260 |

***Notes:***
*CLOOP is Current Loop
**EIA-530 defines connector signal assignment, not voltage levels

***Table 2***

#### 2.3.5 MEDIA CONVERSION

As we note in the next section, the common situation encountered will be where the premises data communications system is implemented with a single media type, usually Unshielded Twisted Pair (UTP) cable. However, you may come upon implementation problems where the system uses mixed media, some combination of UTP, coaxial cable and fiber optic cable. Mixed media usually comes about when the system evolves and specific segments of it may have to operate in a harsh environment such as a factory floor. The UTP with which the premises data communications system began its growth may not provide sufficient protection in such an environment from electromagnetic interference. The better shielding available with either Shielded Twisted Pair (STP), coaxial cable or fiber optic cable may be required.

In implementing such systems you may be faced with converting the signal modes propagating on one media type so that they are appropriate for another. Adapters for such conversions are readily available.

## 2.4 WIRING ADAPTERS

A variant on the problem of interface conversion is that of the plug-a-verter. Consider two data equipment units, again a computer and a printer, both of which have an EIA-232C interface. In this situation there is really no need to do interface conversion. Most people do not realize that data processing systems such as this often use the X-ON/X-OFF characters to control the flow of data. These systems only need three wires to transfer data between the two data devices. They do not need all of the control signals; that is, all of the pins provided by the EIA-232C interface and its bulky and expensive cable. The data can be transferred from the EIA-232C interface using a modular wiring adapter or Plug-A-Verter and skinny modular cable to connect the three wires as shown in Figure 7.

*Figure 7: Plug-A-Verter*

A Plug-A-Verter is simply a DB-25 to RJ-11 adapter. This is not as expensive and takes up much less space. If the two data equipment units require a more complicated handshake or control signal, for example a handshake in one direction, then you can go to the next level of complexity using four wires with a Plug-A-Verter. Using the example of the printer, the printer usually has a busy line which would be the fourth wire.

Another level of complexity is the situation where the data processing system needs a bi-directional handshake. This can be accomplished with a Plug-A-Verter with six wires. All of these Plug-A-Verter schemes are more attractive than using the bulky EIA-232C cable with the full interface. More complex systems can use eight wires. As a final point, note that Plug-A-

Verters with the associated modular interfaces have all kinds of modular support equipment available on the market. These include wall plugs, wiring closets and multiple port harmonicas.

## 2.5 FACTORS INFLUENCING THE CHOICE OF AN INTERFACE CONVERTER

Given that you have to carry out an interface conversion of a certain type there are a number of factors which may influence your choice of a particular converter model. Below are some of these factors although the discussion is not all inclusive.

Chief among these is whether you want the conversion done by an external box, a card in a rack or a card which fits into a slot on the backplane of a computer. The most common converters are external boxes. But, cards are also available for certain situations. A card fitting into a slot on the backplane has the advantage of being able to use the computer's electrical power source as its own.

You may also be concerned about the effects caused by ground loops and look for a converter which has optical isolation.

Finally, you may need a converter with surge suppression built into it or which has Tempest protection for a military application where low emissions are needed for security.

## 2.6 INTERFACE CONVERSION WITH WORK STATIONS

We have mentioned that the self contained work station usually has within it all of its data communication equipment needs. Nonetheless, there are cases where even these self contained work stations need interface converters.

One situation in which this often occurs is when some military agency procures, commercially available, off the shelf, work stations with EIA-232C interfaces. An unexpected need arises to output data from these units to some equipment using one of the military standard interfaces such as MIL-STD-188-144 Type 1. An interface converter then is obviously required.

Another case develops when a work station with only a parallel output (i.e. Centronics) needs to connect to a serial input device (e.g. a plotter) or when one with a serial output needs to connect to a parallel input printer. A bi-directional parallel/serial converter-buffer is then needed. This is an interface converter.

# *CHAPTER 3*

## WIRING ALTERNATIVES - MEDIA

An important concern to users of premises data communications facilities is the type of media needed to connect the interfaces of the data equipment. There are a number of candidates. From the perspective of the user the media choice is influenced by the distance between the data equipment, the desire of immunity to interference and of course cost.

The user is blessed with a number of different media candidates. Topping the list are multi-conductor data, twisted pair, coaxial, and fiber optic cable. Wireless (radio) is also a possibility which is of increasing interest. However, space limitations do not permit any discussion of it.

Data cable is employed when equipment is very close together, within 50 feet. For longer distances, especially beyond several hundred feet, the media alternatives are limited to twisted pair, coaxial and fiber optic cable. All of these media types are discussed below. Undoubtedly, twisted pair is the most widely used. Often we will make comparisons to it.

The reader may find this chapter "overly technical" relative to his/her background and/or needs. If this is the case, my advice is to jump directly to Chapter 4. While you will miss my excellent writing I will keep you interested in reading.

### 3.1 DATA CABLE

When data equipment is very close together, within 50 feet, it can be connected together using EIA-232C cable. This is usually multi-conductor with 25 conductors. Each conductor is dedicated to a different pin of the EIA-232 interface. In most premises data communications applications only a fraction of the 25 EIA-232C pins are needed. For such applications there is RS-232C data cable available with fewer connections e.g. 12. The data cable comes in two types of packages, ribbon and jacketed. The ribbon version should only be employed when the data equipments being connected are a few feet apart. The jacketed version is used for the longer distances. It is generally shielded to reduce interference and has strain relief to relax inadvertent tension in making a connection.

There is a higher quality version of EIA-232C data cable to connect together equipment separated by several hundred feet. This higher quality cable is referred to as low capacitance, extended distance, EIA-232 cable. Its cost is generally five times the cost of ordinary EIA-232 ribbon cable.

When data cable is purchased it usually comes with the EIA-232 DB25 connectors at the terminations.

## 3.2 TWISTED PAIR

Twisted pair cable is exactly what its name represents, two conductors of wire which have been twisted together in order to limit the effects of stray capacitance and cross-talk from adjacent cables. There are usually two twists per foot. It is the least expensive of the connecting media types and the most widely used. There is a simple explanation for this. Generally Unshielded Twisted Pair (UTP) cable is already installed in most buildings or plants, having been put in for other uses. It has its origin in telephony and is familiar to most people as the wire between their phone and the wall jack. Shielded Twisted Pair (STP) exists but it is far more expensive. STP emerged in the early 1980’s when IBM began to use it as an alternative to coaxial cable for their Systems Network Architecture (SNA). It does provide "better performance" than UTP with respect to protection from interference. But, this is only achieved if the shield is properly grounded. If this is not done what you are left with is a more expensive cable which actually yields performance degraded relative to UTP. It suffices to say that many users often do not properly ground the shield.

Connecting communication devices with twisted pair is easy with little in the way of a termination problem. It can support most data rate requirements of premises data communications systems. In fact, recently on short runs, twisted pair has been demonstrated to support transmission rates as high as 10 megabits per second.

Twisted pair conductors come in a number of different "flavors" corresponding to different wire gauges. These are 19AWG, 22AWG, 24AWG and 26AWG. However, 24AWG and 26AWG are most common. The wires are stranded or solid and each wire has a solid or multicolor covering.

As noted in [Ref.1] when choosing the type of twisted pair cabling to employ one needs to consider the following electrical attributes, capacitance (both self and mutual) characteristic impedance, attenuation and velocity of propagation. Such properties of the media are a result of the construction, jacket, insulation, shielding and center conductor. The implications of these parameters are summarized below.

The capacitance measures the electric field energy stored in the dielectric between the conductors of the twisted pair. It is determined by the cable’s dielectric,length and the inter-conductor spacing. Too much capacitance causes signal distortion. There is a rounding of the edges of an originally rectangular shaped data or control signal. This deleterious effect can degrade performance by causing intersymbol interference.

Characteristic impedance measures the resistance to current in the wire. It is a function of frequency as well as the electromagnetic material properties of the cable. Good engineering practice usually dictates a constant characteristic impedance over the entire premises. This minimizes energy loss and makes data communications dependable.

Attenuation is a measure in decibels (dB) of the decrease in signal strength along cable length. Too great an attenuation may reduce the received signal to noise ratio to an unacceptable level, and an intolerable received bit error rate may then result.

The velocity of propagation is the speed of an electrical signal on the cable. It is often expressed as a percentage of the speed of light in a vacuum. Its reciprocal is delay. Too great a delay may ultimately impact transactional response time in the higher level applications.

Table 3 summarizes typical physical parameters for twisted pair cable obtain from well known commercial sources. Table 4 displays important parameters of twisted pair cable as a function of frequency.

**Typical Physical Parameters for Twisted Pair Wiring Cable, Type 3 Cable and Plenum Grade Cable**

| Manufacturer | Part # | Number of Pairs | AWG/Strandling | Capacitance in pF/Ft. | Nominal dc resistance in ohms/1000' | Grade P=plenum N=non-plenum |
|---|---|---|---|---|---|---|
| Belden | *1154A | 4 | 24/solid | 15 | 25.7 | N |
| Belden | *1154A | 4 | 24/solid | 15 | 25.7 | P |
| AT&T | *2082 component #1 | 4 | 24/solid | 11.1 | 25.7 | P |
| AT&T | *2082 component #2 | 4 | 24/solid | 15.9 | 25.7 | P |
| AT&T | DIW 4/24 | 4 | 24/solid | 17.5 | 25.7 | N |
| AT&T | 2001 004D | 4 | 24/solid | 16 | 25.7 | P |
| IBM spec | Type 3 | 4 | 22 or 24/solid | n/a | 28.6 | n/a |

***Table 3***

**Physical Parameters of Unshielded Twisted Pair Cable Obtained From Well Known Commercial Sources**

| **Manufacturer** | **Part #** | **Velocity of Prop.** | **Attenuation in dB/100' at** | | | **Nominal Characteristics impedance in ohms at** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **1 kHz** | **256 kHz** | **1 MHz** | **1 kHz** | **256 kHz** | **1 MHz** |
| Belden | *1154A | 0.60 | n/a | 0.27 | 0.64 | n/a | 105 | 105 |
| Belden | *1155A | 0.60 | n/a | 0.27 | 0.64 | n/a | 105 | 105 |
| AT&T | *2082 Comp. #1 | n/a | 0.035 | n/a | 0.48 | 700 | n/a | 130 |
| AT&T | *2082 Comp. #2 | n/a | 0.044 | n/a | 0.66 | 550 | n/a | 80 |
| AT&T | DIW 4/24 | n/a | 0.046 | n/a | 0.64 | 600 | n/a | 105 |
| AT&T | 2001 004D | n/a | n/a | n/a | 0.30 | n/a | n/a | 100 |
| IBM spec | Type 3 | n/a | n/a | 0.40 | 0.80 | n/a | 90-120 | 84-113 |

***Table 4***

With twisted pair there are four major sources of performance deterioration: noise, distortion, attenuation and crosstalk [Ref. 1]

Excess noise comes from two sources radio frequency interference (radio and television transmitters) and electromagnetic interference (fluorescent lights, arc welders, motors).

Distortion is caused by capacitance and increases with the cable length over which a signal is transmitted.

Excess noise coupled with significant attenuation is a serious problem with twisted pair cable. Long cable runs can realize a low gain antenna and "pick up noise." This coupled with excess attenuation can seriously degrade performance.

An interfering signal in a twisted pair that originates in another pair is termed "crosstalk." The number of cable twists per foot and the dielectric have a significant effect on the amount of crosstalk. The tighter the twists the lower the crosstalk and the more limited its degrading effect.

## 3.3 COAXIAL CABLE

Coaxial cable consists of two cylindrical conductors, one placed concentric within the other, but separated by an insulator. Figure 8 illustrates the anatomy of coaxial cable. As compared to twisted pair, coaxial cable has a much higher signal bandwidth. It can, as a consequence, support much higher data rates. When it is used in a single ended system, that is, when the outer conductor is grounded, there is an inherent shielding capability which unshielded twisted pair does not have. This shielding capability makes transmission immune to Electro-Magnetic Interference (EMI), Radio Frequency Interference (RFI) and other forms of interference. It provides more reliable communication but is generally more costly than twisted pair. On average it is four times more expensive. Also connecting devices to it (the termination problem) is much more difficult.

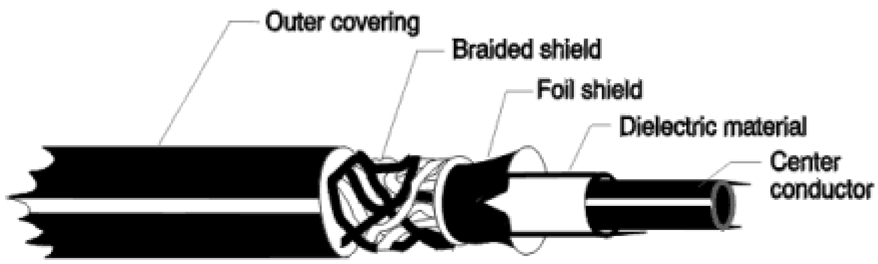



*Figure 8: Detailed Illustration of Segment of Coaxial Cable*

An excellent detailed discussion of the performance characteristics of coaxial cable is provided in [Ref.2]. Particular elements are summarized below.

As illustrated in Figure 8 coaxial cable is a class of cable that is best characterized as having several layers of material surrounding a common axis. A center conductor (solid or stranded) is surrounded by dielectric, or nonconductive, material and then shielded. This shield is often a wire braid or foil jacket, and is covered by an abrasion-resistant jacket. For outdoor applications, the spaces between the dielectric shield, and outer covering can be filled with an inert, waterproof gel for extra protection. This would also be done for buried cable. The dielectric material and outer jacket may be made of plenium or non-plenium material (often Teflon or polyvinyl chloride, respectively).

The cable thickness as well as the composition of the dielectric material, and construction techniques determine the signal properties of a coaxial cable. As with twisted pair, four parameters determine signal quality: characteristic impedance, mutual capacitance, attenuation and velocity of propagation. DC resistance is sometimes mentioned as a fifth parameter. Tables 5 and 6 [Ref.2] provide the electrical and physical characteristics of various types of coaxial cable.

## Electrical Characteristics of Various Types of Coaxial Cable Obtained from Well Known Commercial Sources

| Manufacturer | Part # | Cable Designation | DC resistance ohms/100' | Nominal impedance in ohms | Attenuation in dB/100 feet at N MHz | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 5 | 10 | 50 |
| Belden | 9880 | 10BASE5, E'net | 14.2 | 50 | 0.19 | 0.37 | 0.52 | 1.70 |
| Belden | 9880 | 10BASE5, E'net | 14.2 | 50 | 0.19 | 0.37 | 0.52 | 1.70 |
| Manhattan | M4180 | Thick Ethernet | 14.2 | 50 | N/A | N/A | N/A | N/A |
| Carol | C1154 | Thick Ethernet | 18.7 | 52 | N/A | N/A | N/A | 1.3 |
| Carol | C1152 | Thick Ethernet | 18.7 | 52 | N/A | N/A | N/A | 1.6 |
| Carol | C5015 | Thick Ethernet | 12.4 | 50 | N/A | N/A | N/A | 1.1 |
| Belden | 9907 | 10BASE2, E/net | 95.0 | 50 | 0.43 | N/A | 1.30 | 2.91 |
| Belden | 89907 | 10BASE2, E/net | 95.0 | 50 | 0.43 | N/A | 1.30 | 2.91 |
| Belden | 8259 | 10BASE2, E/net | 108.0 | 50 | 0.44 | N/A | 1.4 | 3.3 |
| Belden | 9201 | 10BASE2, E/net | 101.0 | 53.5 | 0.33 | N/A | 1.2 | 3.1 |
| Carol | C1174 | 10BASE2, E/net | 101.8 | 53.5 | N/A | N/A | N/A | 3.1 |
| Carol | C1172 | 10BASE2, E/net | 88.8 | 50 | N/A | N/A | N/A | 3.2 |
| Carol | C1163 | Arcnet | 550.0 | 93 | N/A | N/A | N/A | N/A |
| Belden | 9268 | Arcnet | 417.0 | 93 | 0.25 | N/A | 0.85 | 1.9 |
| Manhattan | M4276 | Arcnet | 412.0 | 93 | N/A | N/A | N/A | N/A |

*Table 5*

**Physical Characteristics of Various Types of Coaxial Cable Obtained From Well Known Commercial Sources**

| Manufacturer | Part # | Cable Designation | Weight in lbs./500 ft. | AWG | Stranding | Nominal OD (inch) |
|---|---|---|---|---|---|---|
| Belden | 9880 | 10BASE5, E'net | 14.2 | 50 | 0.19 | 0.37 |
| Belden | 89880 | 10BASE5, E'net | 14.2 | 50 | 0.19 | 0.37 |
| Manhattan | M4180 | Thick Ethernet | 14.2 | 50 | N/A | N/A |
| Carol | C1154 | Thick Ethernet | 18.7 | 52 | N/A | N/A |
| Carol | C1152 | Thick Ethernet | 18.7 | 52 | N/A | N/A |
| Carol | C5015 | Thick Ethernet | 12.4 | 50 | N/A | N/A |
| Belden | 9907 | 10BASE2, E/net | 95.0 | 50 | 0.43 | N/A |
| Belden | 89907 | 10BASE2, E/net | 95.0 | 50 | 0.43 | N/A |
| Belden | 8259 | 10BASE2, E/net | 108.0 | 50 | 0.44 | N/A |
| Belden | 9201 | 10BASE2, E/net | 101.0 | 53.5 | 0.33 | N/A |
| Carol | C1174 | 10BASE2, E/net | 101.8 | 53.5 | N/A | N/A |
| Carol | C1172 | 10BASE2, E/net | 88.8 | 50 | N/A | N/A |
| Carol | C1163 | Arcnet | 550.0 | 93 | N/A | N/A |
| Belden | 9268 | Arcnet | 417.0 | 93 | 0.25 | N/A |
| Manhattan | M4276 | Arcnet | 412.0 | 93 | N/A | N/A |

*Table 6*

To get a feel for the meaning of these parameters observe Figure 9. It illustrates the combined effect of attenuation and capacitance on the transmitted signal at some distance from the source.

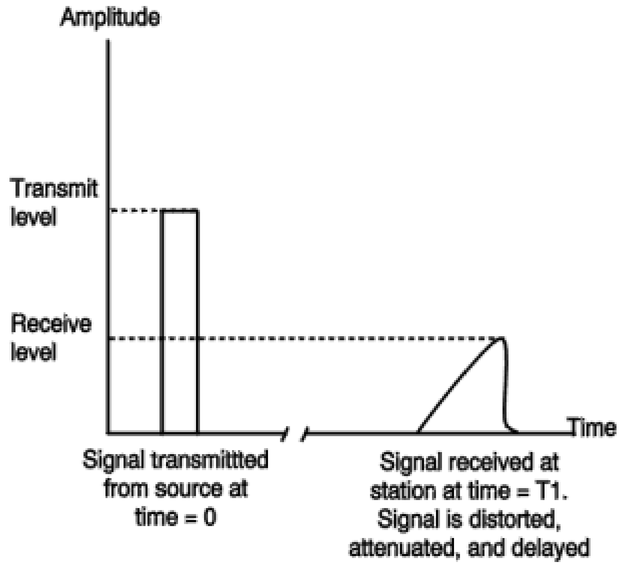



*Figure 9: Illustration Showing Mutual Capacitance and Attenuation Significantly Corrupting a Transmitted Signal on Coaxial Cable*

Determining the correct coaxial cable type for your application can be confusing. Several dozen types are available. The coaxial cable types most often encountered include RG-58, RG-58A, RG-58A/U, RG-58C/U, 802.3 thick and thin ETHERNET cable, RG-8, RG-8/U, RG-59,RG-62,RG-62A and RG-62A/U, all in polyvinyl chloride and plenum equivalents.

Many cable types, such as RG-58C/U, also meet military specifications, ("mil-specs") and may cost more due to the required certification testing.

Proper reference is made to [Ref. 2] as the original source of the figures and tables of this section.

### 3.4 FIBER OPTIC CABLE

Fiber optic cable consists of a strand of glass or plastic. A gradient in the refractive index across the diameter of this strand allows the cable to act as a waveguide for light. This provides the essential communication connectivity. Figure 10 [Ref.3] shows the details of the structure of fiber optic cable.

Fiber optic cable is a cylindrical structure made of a dielectric material transparent in the visible and near-infrared region of the spectrum. This structure consists of an inner region called the "core," where light essentially propagates. It is surrounded by a region called "cladding." This outer region has a refractive index smaller than that of the core. It is this constraining condition which allows light to confined in the core region.

The cladding also serves another function. It provides mechanical protection for the core. However, additional outer protection is usually needed for practical handling. Such additional protection typically consists of plastic material.

The basic material for the cladding is silica ($SiO_2$). For increasing the core refractive index, germania ($GeO_2$) is usually added to silica, while fluorine is typically added to decrease the silica refractive index, when needed.

There are many different fiber optic cable types. Fortunately, they can be conveniently grouped into three broad categories, step-index multimode fibers, graded-index multimode fibers and single mode fibers.

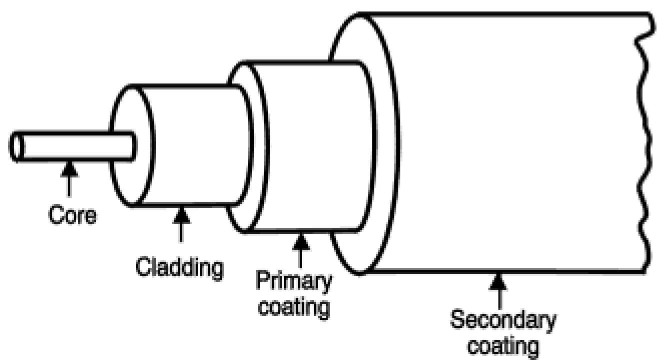



*Figure 10: General Structure of Fiber Optic Cable*

Step-index multimode fibers are characterized by a homogeneous core region with a constant refractive index. As to be expected they are surrounded by a cladding of lower refractive index. Step-index fibers were the first exceptionally low loss fibers to be developed. They have sizes of around 80 um for the core diameter, and 110 to 150 um for the cladding diameter. To date they have not found application in telecommunications outside the laboratory and have not been standardized.

Graded-index multimode fibers exhibit a refractive index profile n(r) (r is the radial coordinate with origin at the core axis). This features a gradual increase from a minimum value n(a) at the core-cladding boundary (generally coincident with the cladding value) to a maximum value of n(0), generally found at the core center. The main advantage of graded-index over step-index fibers is the greatly enhanced bandwidth. This is due to the fact that the speed of the different modes can be almost equalized by suitably shaping the index profile.

Single-mode fibers correspond to the core diameter of the optical fiber taking values comparable to the wavelength of the radiation to be propagated. Reaching this condition allows only the fundamental mode to be guided along the fiber. The most spectacular advantage of single-mode fibers is the increase of bandwidth due to the absence of modal dispersion. The bandwidth limiting factor is essentially constituted by chromatic dispersion which in ordinary step-index profiles has zero value in the region around 1.3 um. As a consequence, with suitably narrow line width sources, the total bandwidth might be two or three orders of magnitude greater than in multimode fibers. Single-mode fibers have other advantages: lower loss, great upgrade capability in view of future ultra-high bandwidth transmission, easy and accurate system design, and compatibility with integrated-optics devices. For these reasons at longer distances than those used in premises data communications single-mode fibers are the only fiber type used. Of course, multi-mode fibers are perfectly acceptable for premises distances.

Essentially, fiber optic cable has a much higher bandwidth than both coaxial cable and twisted pair. Therefore, it has the ability to support much higher data rates. As the demand for bandwidth increases and the cost comes down this will become the media of choice.

The nature of fiber optic cable, the glass or the plastic material from which it is constructed, essentially allows it to have complete immunity to EMI, RFI and other forms of extraneous signals. It is a highly appropriate transmission media for the heavy industrial environment where such forms of interference are a problem. Fiber optic cable is immune to signal leakage and is secure against eaves dropping. It has a much higher reliability than either coaxial or twisted pair. Since fiber optic cable is nonconductive its use eliminates ground loop problems. It also does not need protection from electrical surges or lightning.

Against these advantages it is 25 times more expensive (on average) than twisted pair. Terminating devices to its ends is much more difficult and requires a high degree of skill by the field technician. But, there is some light at the end of this tunnel (No pun intended). Increased demand and utilization in expectation for bandwidth needs is causing cost to come down. Technician handling costs and more convenient termination techniques are likewise arising.

Most fiber optic cable in use today is optimized for operation at either wavelengths of 820 nm or 1300 nm. Table 7 [Ref.4] indicates the attenuation losses of cables at these wavelengths in various situations.

**Fiber Optic Cable Attenuation Losses at Premises Communications Distances**

| Wavelength | Worst-case loss/km | To desk (328 feet) | Between closets (600 feet) | Between buildings (1,000 feet) | Intracampus | |
|---|---|---|---|---|---|---|
| | | | | | (3,000 feet) | (8,200 feet) |
| 820 nm | 4 dB | 0.4 dB | 0.7 dB | 1.2 dB | 3.7 dB | 10 dB |
| 1,300 nm | 1 dB | 0.1 dB | 0.2 dB | 0.3 dB | 0.9 dB | 2.5 dB |

***Table 7***

# *CHAPTER 4*

## EXTENDING DISTANCE - THE NEED FOR SHORT HAUL MODEMS

When two data equipment units are to be connected together and the distance separating them is beyond the maximum specified for their common interface you may resort to extended low capacity cable. When the distance goes beyond the capability of this extended cable or you want the ability to increase the data rate at some future time then you can use signal boosting devices at the terminating ends in order to accomplish the transmission. These signal boosting devices come under a variety of different names. They are referred to as short haul modems, line drivers, or limited distance modems. In this book we will refer to these devices as short haul modems. Examples of some short haul modems manufactured by Telebyte are shown in Figure 11.

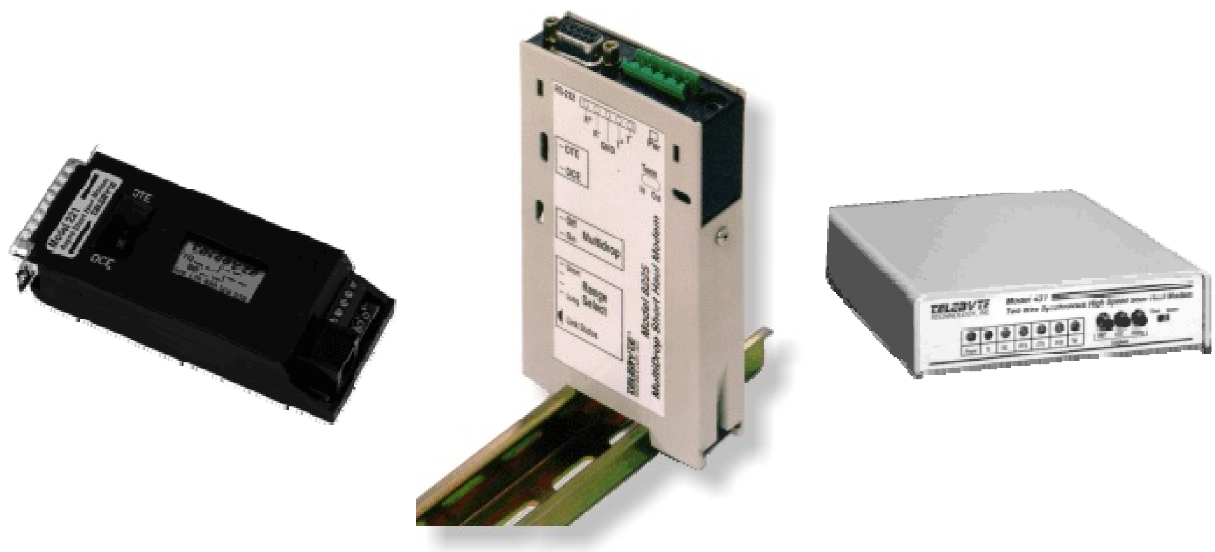


*Figure 11: Examples of Telebyte's Short Haul Modems*

Short haul modems differ in many attributes. It is often a challenge to pick the correct one for your application. Such modems differ with respect to: media driven, data rate supported at a specific distance, ability to serve asynchronous or synchronous traffic and being full duplex or half duplex. Some transfer data only. Others transfer data and control signals.

Along with this short haul modems differ in the way they are powered. Some short haul modems receive their power from a wall transformer while others receive power from a host computer.

Still others utilize power stealing and receive power from the interface signals themselves. The modems may also differ with respect to isolation. Finally, short haul modems have different types of indicators and diagnostic capabilities.

I hope to lead you through the variety of choices available for short haul modems. Most importantly, I hope to provide you with a STEP BY STEP METHODOLOGY for choosing the modem appropriate to your application and avoiding confusion. In any case if you still get confused then Telebyte's excellent customer service staff will help you. They are only an "800" telephone call away.

## 4.1 APPLICATION

As a first step when presented with the need for a short haul modem take a look at the application! You need to answer a few simple questions:

Is the data to be transmitted asynchronous or synchronous (async or sync)? The answer allows you to choose either async or sync modems. Async modems cannot handle synchronous data but some sync modems can operate in an async mode, but they generally cost more. However, many people with a mixed async/sync traffic environment on their premises prefer to use only one type of modem and this leads them to using synchronous modems for all traffic even at a cost penalty.

Take a second look at the application! Do you need only one modem at each location or at one of the locations do you need multiple modems? The application may be just connecting one data equipment unit to only one other unit or it might be transferring data from one equipment unit to multiple sites. If you just need one modem at each location this leads you to the immediate choice of stand-alone modems. On the other hand if at one of these locations you need multiple modems to handle multiple simultaneous transmissions you can use rack mounted modems. This may occur if a multi-user computer system is at one location. These offer more features and are more convenient than having an aggregate of individual stand-alone modems grouped together. Furthermore, you usually are able to use one AC power source for all modems in the rack.

## 4.2 ENVIRONMENT

Take a look at the environment in which communication is to take place! Is it an ordinary office on a single floor? Is it an entire office building where wires may have to be run along side of other electrical conductors through an elevator shaft? Is it a factory where heavy electrical equipment is operating, such as welding equipment, stamping machinery and the like?

If it is an ordinary office then it is probably benign relative to electrical interference such as EMI (Electro-Magnetic Interference) and ground loops. A benign environment does not really drive the choice of the modem. However, if it is one of the environments, where you have interference problems, there is an impact on modem choice. Interference influences the type of communication taking place.

Let’s consider this non-benign situation where there is a possibility of EMI, common mode interference etc. In a non-benign environment you must consider the wiring of the building, the media at the outset. If the existing wiring is old you should consider replacing it. If you can afford it consider fiber optic cable. This cable allows the greatest accommodation to growth in traffic and provides the best protection against EMI. This is especially true in a heavy industrial environment. The use of fiber optic cable leads you immediately to choose short haul modems with fiber optic interfaces. If replacement with fiber optic cable is not possible make sure that you have twisted pair cable with shielding in this non-benign environment. But, make sure that the shielding is properly grounded. Use an optically isolated modem. This eliminates ground loops. Since Telebyte’s Series 70 OPTICALLY ISOLATED short haul modems use differential current to drive the wire they can also protect against EMI and common mode interference.

Take another look at the environment in which the communication is to take place! If the communication is between two buildings then there is the potential for damage to equipment from lightning strikes. Even with buried wire a lightning strike one mile away may generate ground currents which can severely damage equipment. Choose a modem with built-in lightning protection or if you cannot find the appropriate modem obtain one within the constraints of the choices outlined above and use external lightning protection. Such protection devices will be discussed in Chapter 6.

## 4.3 SELECTION

Next carefully look at your computer application in order to determine the maximum speed at which the data has to be transferred in order to run efficiently. Also look at the distance between the communicating equipment. Various vendors have tables indicating the speed versus distance capability of their modem products. Look at the interface required to the data equipment. See if it is the standard DB25 pin connector associated with an EIA-232C serial port or if it is a 9 pin DB9 connector used in PC AT or 386 com ports. Under the constraints of the considerations of the above paragraphs pick out one of the modems from the table of Telebyte’s modem products given in Table 8.

Short haul modems may be either AC powered or host powered. AC powered modems require a wall transformer, the use of an outlet and are usually more expensive. However, They always have the correct power level for the internal components. They provide better performance for a wider mix of equipment and can support LED indicators.

Host powered modems are divided into two types, Control Signal Powered types and Data Powered types. The Control Signal Powered modem derives power from the control signal on the interface pins CTS/RTS or DSR/DCD/DTR. The Data Powered modem derives power from the data pins, TD and RD. Host powered modems are less expensive than AC powered modems and do not need a wall outlet. Data powered modems are typically more expensive than Control Signal Powered Modems since they require additional circuitry to generate the DC voltages from the Transmit Data signal. Furthermore, they only provide reliable communication with data equipment if the voltage levels are known to be well within operating range required by the modems.

Host powered modems cannot afford to use any power for LEDs therefore they are not utilized. If these visual aids are necessary AC powered units should be used.

Finally, look at the application and the need to transport either data only or data and handshake signals. Some short haul modems will only transmit data. Others will transmit both data and one or more control signals such as CTS, RTS etc. The control signals change at a rate far below the data rate. Their transmission allows handshakes to be effected. Usually, their transmission is executed by some type of "side channel" which of course adds to complexity and cost.

**Short Haul Modem Selection Guide**

| Model (note1) | Protocol | Wire or Fiber | Full Duplex & Handshake | Max Speed KBPS | Number of Wires | Number of LED's/ LCD's | Power Source (note2) | Physical Type (note3) | List Price |
|---|---|---|---|---|---|---|---|---|---|
| 72A | ASYNC | W | No | 19.2 | 4 | 2 | AC | SA | $99 |
| 75 | ASYNC | W | No | 19.2 | 4 | 4 | DC | RM | $125 |
| 77 | SYNC | W | Yes | 19.2 | 4 | 6 | DC | RM | $198 |
| 79 | ASYNC | W | Yes | 19.2 | 4 | 8 | DC | RM | $195 |
| 91 | SYNC | W | Yes | 19.2 | 4 | 7 | AC | SA | $260 |
| 92 | SYNC | W | Yes | 19.2 | 4 | --- | TD/PS | SA | $175 |
| 201 | ASYNC | W | No | 19.2 | 4 | --- | TD | SA | $70 |
| 203 | ASYNC | W | No | 19.2 | 2 | --- | TD | SA | $82 |
| 209F | ASYNC | W | No | 19.2 | 4 | --- | TD | SA | $72 |
| 214A | ASYNC | W | No | 38.4 | 2 | 1 | AC | SA | $148 |
| 221 | ASYNC | W | No | 19.2 | 4 | LCD | TD | SA | $95/$72 |
| 224 | ASYNC | W | Yes | 19.2 | 4 | LCD | AC | SA | $125 |
| 225 | ASYNC | W | Yes | 19.2 | 4 | LCD | TD | SA | $120/$99 |
| 226 | ASYNC | W | Yes | 19.2 | 4 | LCD | TD | SA | $114/$91 |
| 227 | ASYNC | W | No | 115.2 | 4 | LCD | TD | SA | $109/$86 |
| 271 | ASYNC | F | No | 56 | 2 Fibers | --- | AC | SA | $145 |
| 272 | ASYNC | F | No | 2500 | 2 Fibers | --- | AC | SA | $152 |
| 274 | SYNC/ASYNC | F | Yes | 256 | 1 Fiber | 6 | AC | SA | $425 |
| 276 | ASYNC | F | No | 1000 | 2 Fibers | --- | AC | SA | $152 |
| 277 | ASYNC | F | No | 1000 | 2 Fibers | 4 | AC | SA | $275 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 278 | SLIP/PPP | F | Yes | 115.2 | 2 Fibers | 10 | AC | SA | $298 |
| 420 | SYNC | W | Yes | 128 | 4 | 6 | AC | SA | $475 |
| 431 | SYNC | W | Yes | 128 | 2 | 6 | AC | SA | $575 |
| 681 | *HDSL* | W | Yes | 128 | 4 | LCD | AC | SA | $1195 |
| 8361 | ASYNC | W | No | 115.2 | 4 | 2 | AC | DIN | $250 |
| 8362 | ASYNC | W | No | 38.4 | 4 | 2 | AC | DIN | $266 |

***Pick the Modem That's Best for Your Allpication***
*Notes:*
1. All standalone Short Haul Modems except Models 209, 420, 431, 91, and 92 are available with male or female RS-232 connectors.
Please specify M or F when ordering.
Model 209F is a DB9 female connector to match the PC com port of a PC
Model 431 has a DB25 female connector.

2. Power Source: TD = Transmit Data, PS = Power Stealing (takes power from pins 4,5,6,8, or 20), DC = Host Powered, AC = Self Powered (comes with a wall mounted transformer.)

3. Physical: Standalone (SA) or Rack Mount (RM)

***Table 8***

**4.4 PC EXTENDERS**

We have said that a short haul modem is essentially a signal boosting device for connecting data equipment over long premises distances. There are a number of devices similar to the short haul modem but specifically oriented to the needs of the Personal Computer (PC). Basically, they allow the PC to operate remotely from its attached, external components. These are usually referred to as Printer, Mouse, Video Display or Keyboard Extenders. They are not widely available but they are available. They are principally used on the trading room or factory floor where the PC user may be quite remote from the PC itself.

# *CHAPTER 5*

## RESOURCE SHARING

Within the premises data communication environment economies can be gained by sharing resources. Such resource sharing may take a number of different forms. The communication capacity, that is the actual cable, can be shared by a number of different data sources or their applications. Communication and peripheral equipment can also be shared.

### 5.1 MULTIPLEXING

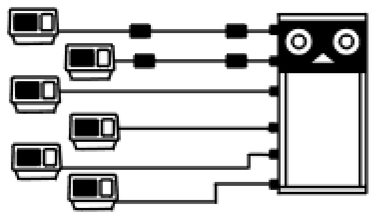
Let's consider the problem of capacity sharing first. If you were to take a careful look at the actual cable connecting a single pair of communicating data equipments you would find that its signalling capacity, the rate at which it can transfer data, probably far exceeds the needs of the particular data processing application being run. To the point, of course the cable can be used to connect a single data equipment type to another isolated data equipment type. However, in general, the data transferred in a single application is far less than the actual capability of the wire. You can then conclude that the single cable need not be dedicated just to a single pair of communicating data units. Rather, it can be shared among a number of different users.

You may ask how may this sharing occur and the resultant cable cost reduction be achieved? It is really quite simple. Consider the top illustration, Figure 12. Here is a group of different terminals. Also shown is a multi-user computer to which the terminals must be connected. the computer may be somewhere else on the premises perhaps in the basement of the office building.

When the terminals are scattered throughout the building the most straightforward approach to connecting them to the computer is also probably (close to) the most economical. This is shown in the middle illustration of Figure 12. Here, each terminal has its own dedicated pair of wires connecting it to the computer. Short haul modems are used for signal boosting if required.

When the group of terminals is not scattered but clustered in the same office or floor there is a more economical alternative. A single cable pair has the capability to effect the transfer of the data from all the terminals. Consequently, the cluster of terminals can share the single cable bringing about a savings in cabling and equipment costs. A device called a short haul multiplexer is required to bring about the efficient and reliable sharing of the single cable. The bottom illustration of Figure 12 shows this. The cabling cost here is one-sixth that of the the situation shown in Figure 12B with the terminals at the same locations. Of course, one has to compare the cost of the short haul multiplexer with its significant intelligence with that of the distinct short haul modem pairs to determine the actual cost savings.

*Figure 12A:Terminal Cluster Isolated from Multi-user Computer*



Note:All Terminals Use Short Haul Modems to
Support Cable Lengths in Excess of 50 Feet

*Figure 12B:Terminals in cluster each connected by dedicated cables to multi-user computer*

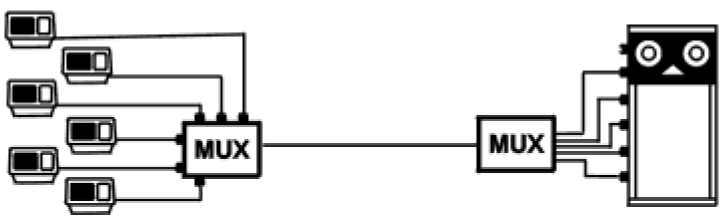



*Figure 12C:Terminals sharing a single cable to multi-user computer by multiplexing*

Different short haul multiplexers manufactured by Telebyte are shown in Figure 13.

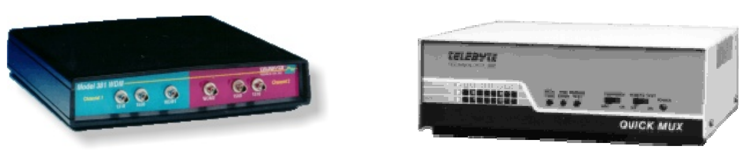



*Figure 13: Telebyte Short Haul Multiplexers*

Short haul multiplexers operate in a number of different ways. The most common way is to share time on the cable between the different terminals. This is usually referred to as time division multiplexing (TDM). More advanced forms of short haul multiplexers, such as the Telebyte Model 570 Quick Mux, have the ability to incorporate bi-directional control signals for each terminal. Short haul multiplexers generally incorporate specialized short haul modems necessary to effect the signaling on the line.

When considering short haul multiplexing as an economic measure in your premises data communication environment you should be aware of a number of different issues. These are brought to your attention now.

To begin with there is the number of ports that the short haul multiplexers can support. This limits the number of terminals that can be plugged into it and can share the cable.

Be aware of the port speed. This limits the maximum data that can be transferred from a data equipment unit into the multiplexer.

Pay attention to the aggregate speed on the output side of the multiplexer driving the line. You obviously need transmission media which can support the aggregate speed.

Be concerned with the possible problem of lightning protection. Often the situation arises where the cluster of terminals is located in one building and the multi-user computer is in another building. The interconnecting line must be protected. Even if buried it is subject to lightning strikes and appropriate lightning protection must be present.

Within short haul multiplexers there are a number of different types. Some are stand-alone, others are integrated as cards within the computer themselves.

Finally, be concerned with the transmission media employed. Besides short haul multiplexers for twisted pair cable there are ones which interface fiber optic cable. Telebyte's Model 575 short haul multiplexer mated with Model 275 adapter is one such example.

## 5.2 PORT SHARING

Port sharing devices allow a number of different DTE's to share the same peripheral such as a printer, plotter, or a high speed modem. This sharing can be accomplished via a simple mechanical switch or sophisticated electronic devices. With simple devices there is an external switch, which physically must be thrown to allow one data equipment unit to seize control of the peripheral. Somewhat more complicated than the mechanical port sharing devices are equipments which are active and allow terminals or computers to share expensive peripherals. Such devices generally go under the name of modem sharing units, peripheral sharing units or modem allocating units. These allow computers or terminals to share the peripherals on a contention basis. The sharing unit resolves the contention. Usually, these devices operate by polling the connecting terminals, seeing which has raised an RTS flag thus requesting use of the peripheral. The sharing unit then grants the requesting terminal access to the peripheral terminal while keeping other terminals waiting for its use.


*Figure 14: Telebyte's Port Sharing Devices, Models 335 and 576*

When considering such sharing units there are a number of facts which you must know. To begin with know the number of ports, that is the number of terminals which can share the peripheral and the signal lines supported. You must know the speed which data can be transferred through the device to peripheral. You would like to know the dwell time and polling cycle time. In other words know how long it will take for the sharing device to connect you through to the peripheral beginning with the first service request if nobody else is demanding connection. You would like to know if received data is routed only to the selecting terminal or broadcast to all connecting devices. Finally, you would like to know if the sharing unit has internal buffering so that it can save data if the connecting terminal or peripheral is not ready to receive it and control signals cannot effectively throttle the flow.

# *CHAPTER 6*

## LIGHTNING AND .... SURGE PROTECTION

I have alluded to the possible problems caused by lightning and also by other electrical surges in the premises data communications environment. It is now the place to discuss these at more length.  Lightning has long fascinated the technical community. Ben Franklin studied lightning's electrical nature over two centuries ago and Charles P. Steinmetz generated artificial lightning in his General Electric laboratory in the 1920's. As someone concerned with premises data communications you need to worry about lightning. Here I will elaborate on why, where and when you should worry about lightning. I'll then discuss how to get protection from it.

### 6.1 WHY WORRY ABOUT LIGHTNING?

It is unfortunate, but a fact of life, that computers, computer-related products and process control equipment found in premises data communications environments can be damaged by high-voltage surges and spikes. Such power surges and spikes are most often caused by lightning strikes. However, there are occasions when the surges and spikes result from any one of a variety of other causes. These causes may include direct contact with power/lightning circuits, static buildup on cables and components, high energy transients coupled into equipment from cables in close proximity, potential differences between grounds to which different equipments are connected, miswired systems and even human equipment users who have accumulated large static electricity charge build-ups on their clothing. In fact, electrostatic discharges from a person can produce peak Voltages up to 15 kV with currents of tens of Amperes in less than 10 microseconds.

A manufacturing environment is particularly susceptible to such surges because of the presence of motors and other high voltage equipment. The essential point to remember is, the effects of surges due to these other sources are no different than those due to lightning. Hence, protection from one will also protect from the other.

When a lightning-induced power surge is coupled into your computer equipment any one of a number of harmful events may occur.

Semiconductors are prevalent in such equipment. A lightning-induced surge will almost always surpass the voltage rating of these devices causing them to fail. Specifically, lightning-induced surges usually alter the electrical characteristics of semiconductor devices so that they no longer function effectively. In a few cases, a surge may destroy the semiconductor device. These are called "hard failures." Computer equipment having a hard failure will no longer function at all. It must be repaired with the resulting expense of "downtime" or the expense of a standby unit to take its place.

In several instances, a lightning-derived surge may destroy the printed traces in the printed circuit boards of the computer equipment also resulting in hard failures.

Along with the voltage source, lightning can cause a current surge and a resultant induced magnetic field. If the computer contains a magnetic disk then this interfering magnetic field might overwrite and destroy data stored in the disk. Furthermore, the aberrant magnetic field may energize the disk head when it should be quiescent. To you, the user, such behavior will be viewed as the "disk crashing."

Some computer equipment may have magnetic relays. The same aberrant magnetic fields which cause disk crashes may activate relays when they shouldn't be activated, causing unpredictable, unacceptable performance.

Finally, there is the effect of lightning on program logic controllers (PLCs) which are found in the manufacturing environment. Many of these PLCs use programs stored in ROMs. A lightning-induced surge can alter the contents of the ROM causing aberrant operation by the PLC.

So these are some of the unhappy things which happen when a computer experiences lightning. But you may say, "Come on, equipment hit by lightning, that's like winning the lottery. It has never happened and I doubt that it ever will." This is a typical reaction and unfortunately it is based on ignorance. True, people may never, or rarely, experience, direct lightning strikes on exposed, in-building cable feeding into their equipment. However, it is not uncommon to find computer equipment being fed by buried cable. In this environment, a lightning strike, even several miles away, can induce voltage/current surges which travel through the ground and induce surges along the cable, ultimately causing equipment failure. The equipment user is undoubtedly aware of these failures but usually does not relate them to the occurrence of lightning during thunderstorm activity since the user does not experience a direct strike.

In a way, such induced surges are analogous to chronic high blood pressure in a person; they are "silent killers." In the manufacturing environment, long cable runs are often found connecting sensors, PLCs and computers. These cables are particularly vulnerable to induced surges.

## 6.2 WHY WORRY ABOUT LIGHTNING?

This question primarily relates to the geographical location of computer equipment end-users. When other interfering phenomena which can cause a deterioration of performance is considered, it matters little where the equipment is geographically located.

Unfortunately, this is not the case with lightning. Life is unfair for computer users in certain regions of the United States. Take a look at the map shown in Figure 14.

Produced by the Electric Power Research Institute, the map denotes the mean annual days of thunderstorm activity for the continental United States. Upon examination, the map shows the high point of the thunderstorm activity as being in western Florida. It also shows a ripple effect out from this focus of lightning activity. In addition, it shows several areas outside of the southeast where intense thunderstorm activity perturbs the "dying ripple." Notice, for example, the intense areas of Colorado, New Mexico and Arizona. Also observe that the high level of the southeast extends all the way west to Texas.

There are a number of other maps of thunderstorm activity which you may find of interest. These include: 1) National Weather Service map showing average number of annual thunderstorm days by regions, 2) IEEE Working Group Report indicating Thunderstorm-Hour Data in various regions and 3) Annual Lightning flash contours. These maps are available from the author on request.

Examining the map shown in Figure 14 and the other referenced maps pretty much answers the original question. If you're in Florida, lightning protection absolutely must be a concern. In fact, it should be throughout the whole southeast United States extending west to Texas and northwest to Missouri. The map shows where other intense pockets of activity occur. Apparently, only the Pacific coast can be "light hearted" about lightning as a problem.

For outside the continental United States the principal source for lightning statistics is a "world thunderday map" produced by the World Meteorological Organization of Geneva Switzerland. The map is very detailed but I have still produced it here in Figure 16. Yes, it is difficult to read without a magnifying glass. Call me if you want an enlarged copy. But, I will make a few observations.

Notice that outside the continental United States the places to worry about lightning are Mexico, Central and South America, Southern Africa and the southern Pacific Rim. These are all locations where manufacturing activities are on the rise and consequently, lightning will pose more of a problem than in the past.

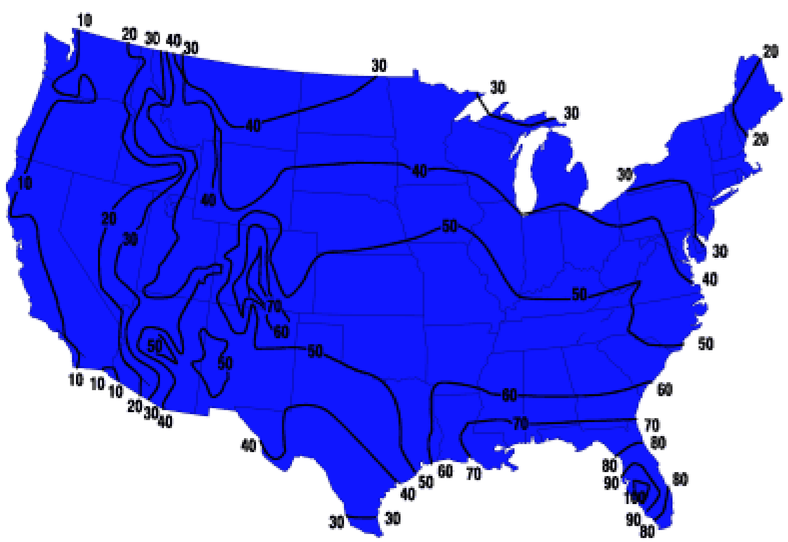



*Figure 15: Mean Annual Days of Thunderstorm Activity in the Continental United States*

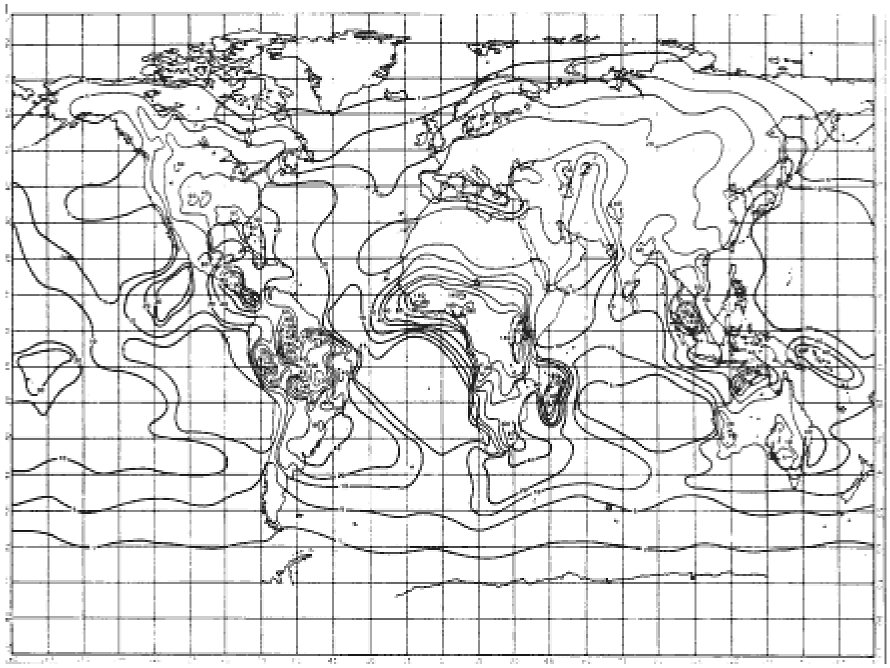


*Figure 16: World Thunderday Map Produced By the World Meteorological Organization of Geneva Switzerland*

One passing note, these maps show contours in terms of number of thunderdays. A more accurate characterization of lightning in a geographical region would be by the lightning flash density, the rate at which flashes occur. There may be many flashes on a given thunderday. It is flash density which is the real parameter of interest in choosing lightning protection. Unfortunately, for outside the continental United States there is even less quantitative data about lightning flashes than about thunderdays. It is possible to relate flash density to the number of thunderdays. In fact, there are a number of such relations. Most are of the form:

Ng = a Tb per km per km per year.

Here Ng is the ground flash density, T the annual thunderdays and a and b empirical constants. Typically, a = 0.1 -to- 0.2 and b=1.

**6.3 WHEN SHOULD YOU WORRY ABOUT LIGHTNING?**

This question really deals with two separate issues: 1) What is the seasonal variation of lightning and 2) What is the variation during a thunderstorm.

At present, the seasonal variation question can only be answered in detail for the continental United States. It is only here that significant measurements have been made and analyzed. The lightning season in the continental United States extends from April until October. Figure 16 illustrates this seasonal variation. The figure is based upon over 13.4 million cloud-to-ground lightning flashes as recorded by the National Lightning Detection Network. Notice the slow rise in the lightning rate in the Spring and the relatively fast decrease in the Fall during 1989.

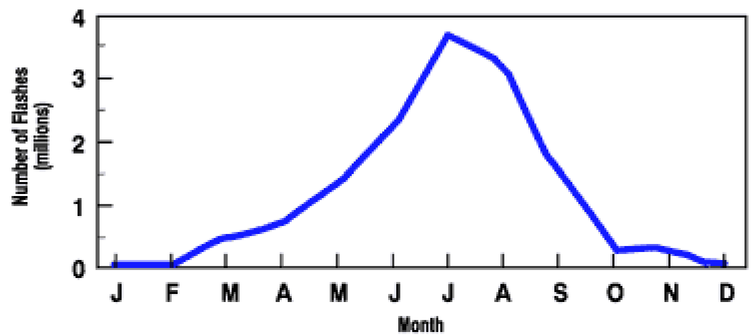



*Figure 17: Seasonal Variations of Lightning in 1989*

Elsewhere in the world it is much more difficult to characterize the daily and seasonal behavior of lightning. Simply put, there have not been intensive efforts to date to collect the data. However, the situation is not completely vacuous. The availability of near Earth orbiting satellites has made it possible to map, in a limited way, worldwide lightning activity by detecting the electromagnetic (light and radio frequency) emissions of a discharge. From experiments reported and carried out by a number of distinguished scientists the following points have been made (under the caveat that they are still based on very limited data):

1) There is 1.4 times more lightning flashes during the summer in the Northern Hemisphere than in the Southern Hemisphere.

2) 37% of the global lightning activity originates over the ocean at dawn and 15% at dusk.

3) The global lightning flash rate is estimated at 64 per second for the Northern Hemisphere Spring, 55 per second for the Northern Hemisphere Summer, 80 per second for the Northern Hemisphere Fall and 55 per second for the Northern Hemisphere Winter.

When do you have to worry during a thunderstorm? Typically, thunderstorms are characterized as intense individual rain cells or showers embedded in a broad area of light rain. These intense cells are only over a fixed location for a few minutes. They are on average, several miles in each direction. In the continental United States thunderstorm cells move from west to east along a squall line as shown in Figure 17. This squall line is about 12-30 miles in width and up to 1,250 miles long. The speed at which the thunderstorm cell moves is generally 30 knots (approximately 34.4 statute miles per hour).

Remember when I raised the question about the possible effects of induced voltage/current surges from lightning striking several miles from computer equipment. Taking this into account, you may believe that a thunderstorm has passed by and the vulnerability to damage has ceased. Actually, a moving thunderstorm having passed, but striking several miles away, may still cause damage. The time interval of vulnerability may be tens of minutes depending upon whether the cell is moving directly along the squall line or obliquely to it.

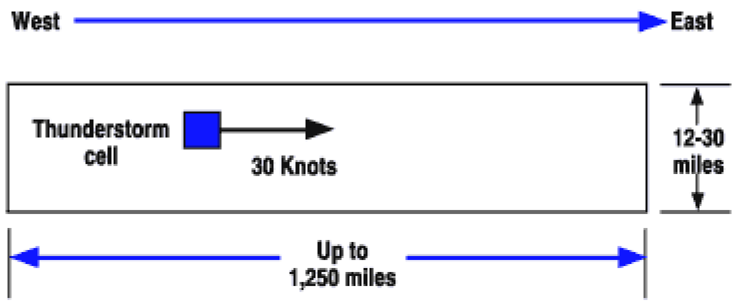



*Figure 18: Thunderstorm Cell Movement*

### 6.4 WHEN SHOULD YOU WORRY ABOUT LIGHTNING?

Coming right down to it, a lot can be done as far as protection is concerned. However, it is best to begin by describing the magnitude of the threat from which you need protection.

The first stroke of lightning during a thunderstorm can produce peak currents ranging from 1,000 to 100,000 Amperes with rise times of 1 microsecond. It is hard to conceive of, let alone protect against, such enormous magnitudes. Fortunately, such threats only apply to direct hits on overhead lines. Hopefully, this is a rare phenomenon.

More common is the induced surge on a buried cable. In one test, lightning-induced voltages caused by strokes in ground flashes at distances of about 5 km were measured at both ends of a 448 meter long, unenergized power distribution line. Typical test results are illustrated in Figure 18. Notice that the maximum-induced surge exceeds 80 Volts peak-to-peak. This is more than enough to destroy semiconductor devices and computer related equipment. Yet, 80 Volts is well within the range of affordable protection.

Conceptually, lightning protection devices are switches to ground. Once a threatening surge is detected, a lightning protection device grounds the incoming signal connection point of the equipment being protected. Thus, redirecting the threatening surge on a path-of-least resistance (impedance) to ground where it is absorbed.

Any lightning protection device must be composed of two "subsystems," a switch which is essentially some type of switching circuitry and a good ground connection-to allow dissipation of the surge energy. The switch, of course, dominates the design and the cost. Yet, the need for a good ground connection can not be emphasized enough. Computer equipment has been damaged by lightning, not because of the absence of a protection device, but because inadequate attention was paid to grounding the device properly.

The basic elements used as protective switches are: gas tubes, metal oxide varistors and silicon avalanche diodes (transorbs). Each has certain advantages and disadvantages.

Because they can withstand many kilovolts and hundreds of Amperes, gas tubes have traditionally been used to suppress lightning surges on telecommunications lines. This is just what is needed to protect against a direct strike. Because gas tubes have a relatively slow response time, this slowness lets enough energy to pass to destroy typical solid state circuits.

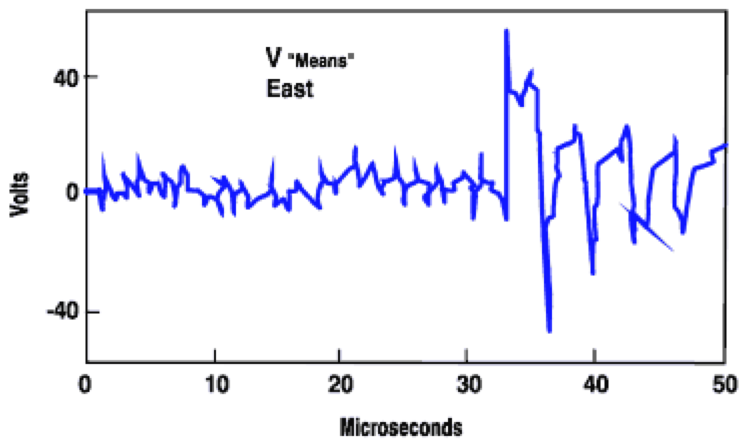



*Figure 19: Measured Induced Voltage*

Metal oxide varistors (MOVs) provide an improvement over the response time problem of gas tubes. But, operational life is a drawback. MOVs protection characteristic decays and fails completely when subjected to prolonged over voltages.

Silicon avalanche diodes have proven to be the most effective means of protecting computer equipment against over voltage transients. Silicon avalanche diodes are able to withstand thousands of high voltage, high current and transient surges without failure. While they can not deal with the surge peaks that gas tubes can, silicon avalanche diodes do provide the fastest response time.

Thus, depending upon the principal threat being protected against, devices can be found employing gas tubes, MOVs, or silicon avalanche diodes. This may be awkward, since the threat is never really known in advance. Ideally, the protection device selected should be robust, using all three basic circuit breaker elements. The architecture of such as device is illustrated in Figure

19. This indicates triple stage protection and incorporates gas tubes, MOVs and silicon avalanche diodes as well as various coupling components and a good ground.

With the architecture shown in Figure 19 a lightning strike surge will travel, along the line until it reaches a gas tube. The gas tube dumps extremely high amounts of surge energy directly to earth ground. However, the surge rises very rapidly and the gas tube needs several microseconds to fire.

As a consequence, a delay element is used to slow the propagation of the leading edge wavefront, thereby maximizing the effect of the gas tube. For a 90 Volt gas tube, the rapid rise of the surge will result in its firing at about 650 Volts. The delayed surge pulse, now of reduced amplitude, is impressed on the avalanche diode which responds in about one nanosecond or less and can dissipate 1,500 Watts while limiting the voltage to 18 Volts for EIA-232 circuits. This 18 Volt level is then resistively coupled to the MOV which clamps to 27 Volts. The MOV is additional protection if the avalanche diode capability is exceeded.

The robust structure shown in Figure 19 is embodied in Telebyte's Model 22. This is shown in Figure 20. The Model 22 is designed to protect 4-wire lines as used in short haul modems operating at speeds up to 38.4 kBaud. Table 9 indicates other Telebyte lightning protection products.

As previously mentioned, the connection to earth ground can not be over emphasized. The best earth ground is undoubtedly a cold water pipe. However, other pipes and building power grounds can also be used. While cold water pipes are good candidates you should even be careful here. A plumber may replace sections of corroden metal pipe with plastic. This would render the pipe useless as a ground.

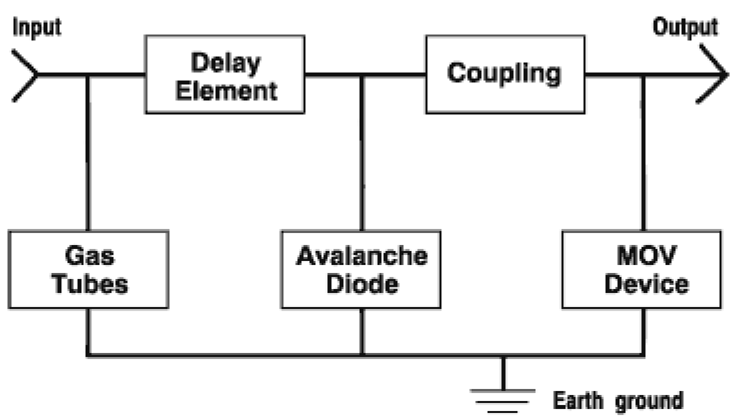



*Figure 20: Architecture of a Robust Protection Device*

*Figure 21: The Telebyte Model 22 Lightning Protection Device*

**Lightning and Surge Protector Selection Charts**

## *Data Transmission and Lightning Protection for Exposed Cable*

| Port | Pins (Protected) | Connector | Ground | Rating | Stages Per Line | Remarks | Model | Price |
|---|---|---|---|---|---|---|---|---|
| RS-232 | 2,3,7 | DB25 | Screw | 1500W | 2(GT+AD) | Reversible- 3 independent circuits:<5 Ohm | 24 | $68 |
| Short Haul, RS-232 | T+, T- R+,R- | Screw R+,R- RJ-11 | Screw Terminal | 1500W | 3(GS+AD+MOV) | 22=Screw Terminals; 22P=RJ-12;<38.4KBPS;4circuits;±14 Volts | 22<br>8022<br>22P | $75<br>$139<br>$75 |
| RS-422 | T+, T- R+,R- | Screw | Screw Terminal | 1500W | 2(GT+AD) | 4 Wire; Up to 5 MBPS; Output limited to ±7.5 Volts | 22NX<br>8021NX<br>8022NX | $69<br>$75<br>$125 |
| 50 Line Data PBX | All 50 | Telco 50 Pin Champ M/F | Screw Terminals | 500W | 2(GS+AD) | Protects RS-232 levels:16 Volt clamp; 3-nanosecond response; impulse: 1000 Amps max on PBX; <100 KBPS; male in-female out | 342<br>*CALL* | $375 |

## *Telephone Lightning Protection for Exposed Cable*

| Port | Pins (Protected) | Connector | Ground | Rating | Stages Per Line | Remarks | Model | Price |
|---|---|---|---|---|---|---|---|---|
| 2-Wire Dial-Up | Tip+Ring | RJ-12 | Screw Terminal | 500W | 3 | Output ±180 Volts;<38.4 KBPS (GT+AD+MOV) | 22PX | $69 |
| 50-Line | Telco 50 Pins | Telco 50 Pin Champ M/F | Screw Terminal | 500W | 2(GS+AD) Terminal | 200 Volt clamp; 5 nanosecond response time; 2 Ohm resistance | 343 *CALL* | $438 |

## *Hi- Speed Telco Lightning Protection for Exposed Cable*

| Port | Pins (Protected) | Connector | Ground | Rating | Stages Per Line | Remarks | Model | Price |
|---|---|---|---|---|---|---|---|---|
| T-1 | 4 wire | RJ-45 | Screw Terminal | 1500W | 3(GT+2AD) | 1.5 MBPS; output limited to ±5V | 22T1 | $69 |
| 56KB | 4 wire | RJ-45 | Screw Terminal | 1500W | 3(GT+2AD) | 56 KBPS; Output limited to ±3V | 2256 | $89 |
| 56KB | 4 wire | RJ-45 | Screw Terminal | 1500W | 4(fuse+GT+2AD) | 56 KBPS; Output limited to ±3V | 2356 | $97 |

| *Data Transmission Lightning Protection for Buried Cable* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Port** | **Pins (Protected)** | **Connector** | **Ground** | **Rating** | **Stages Per Line** | **Remarks** | **Model** | **Price** |
| RS-232 | All 24 | DB25 M/F | Stud | 600W | 1(AD) | Full interface protection | 27A1 | $48 |
| RS-422<br>EIA-530<br>MIL-STD<br>188-114 | All 24 | DB25 M/F | Stud | 600W | 1(AD) | Full interface protection | 27A2 | $48 |
| PC COM PORTS 386/486 | All 9 | DB9 M/F | Stud | 600W | 1(AD) | RS-232 levels; RS-422 levels; EIA-530/188-114 | 29<br>29-1 | $44<br>$44 |

# *CHAPTER 7*

## TEST EQUIPMENT

Test equipment that the user requires in the premises data communications environment varies from very simple devices to extremely complicated devices.

### 7.1 LOW COST DATA LINE ANALYZER

At the low end are simple line monitors referred to by a variety of different names. Telebyte calls its data line analyzer the Model 301 which is shown in Figure 21. This typical low end unit is made up of two components. It includes a data line monitor, the Model 43 Micropeeper, that allows the user to determine the actual status of the seven key signals of the RS-232 data path. All of the 25 signal leads are usually passed through with the seven key signals TD, RD, RTS, CTS, DSR, DCD and DTR being monitored and their status indicated on a set of dual colored LED's. The LED's show whether or not the EIA-232 pin is high, low or has no signal. The Model 301 also includes the Model 151 Mini-Patch Box to allow altering the connections in the data path.

### 7.2 DATA ANALYSIS - PC

A step up from such low end units are add-on cards for the PC, which allow the personal computer to perform as a full featured line monitor. These cards plug into a PC and convert it to a test instrument. They typically have the capability of viewing the bi-directional data and the controls signals of any EIA-232 communication link. The PC display allows visual presentation of the data on a serial line. It allows the operator to understand, quickly, the relationships between transmit data, receive data and the various control leads such as Request-to-Send and Clear-to-Send.

An example of such a test unit is Telebyte's Model 903 PC Comscope shown in Figure 22. The Model 903 consists of a plug in card and a T cable, which allows the PC to tap into and capture the data flowing between data equipment devices. The PC Comscope allows the protocol that is used in the data transmission to be verified. It enables maintenance personnel easily to identify open data leads, missing clock signals, parity errors, incomplete handshakes, etc. It also allows you to emulate protocols such as BISYNC, X.25 and HDLC. Bit Error Rate Test (BERT) capability is also provided by the unit. This test device effectively lets you design your own protocol analyzer. The Model 903 operates in PC AT/386/486 machines or compatibles including lap tops.

While test instruments like the Model 903 are convenient they do have a significant limitation. They depend upon a spare slot being available in the PC platform which is their home.

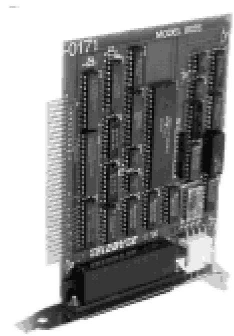


*Figure 22: Low Cost Data Line Analyzer*

*Figure 23: Model 903 PC Comscope*

With the proliferation of add-on boards a slot for the Model 903 may not always be available. This is especially a problem if one wants to use a notebook PC. Telebyte addressed this issue by developing the Model 904 PC Notebook Comscope Protocol Analyzer. It is a small portable unit which is external to the PC but works with it via its serial port. The Model 904 is illustrated in Figure 23.

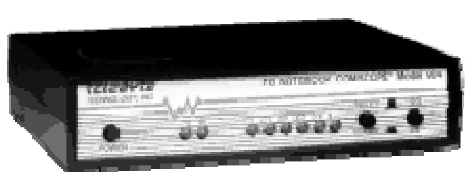


*Figure 24: Model 904 PC Notebook Comscope Protocol Analyzer*

## 7.3 PROTOCOL ANALYZER

Beyond this are datascopes which both monitor and emulate data sources. These allow quality assurance of communication circuits by doing a variety of tests. Datascopes are not usually put in as part of the PC but stand-alone with their own keyboards and screens. Depending on what the user is willing to pay he can have increasing speed and more and more features. Telebyte's Model 901 Netscope was an example of such a tester. A photograph of the Model 901 is shown in Figure 24. However, such test units have lost ground to the PC based equipment.

## 7.4 FUTURE TRENDS

It is always dangerous to predict the future. Nonetheless, at present, we appear to be in the midst of a revolution with respect to datacom test equipment and certain trends are evident. The PC has become ubiquitous. As a result, field service technicians can generally count on a PC being present and available for their use no matter where they are sent. The technician need only put a card like the Model 903 in his attache case when going into the field and then commandeer an available PC. This we see as the "new portability."

Where does this leave the stand alone test units like the Model 901 Netscope? While the Model 901 was retired other stand alone types will not disappear. Rather, they will increase in capabilities especially in the areas of display and archival memory. The increase in capabilities will be matched by a high price. Their use will thus be limited to the laboratory rather than as a portable tool for the traveling technician.

*Figure 25: Model 901 Netscope*

# *CHAPTER 8*

## LOCAL AREA NETWORKS

The subject of this book is premises data communications. I noted in Chapter 3 that there were three architectural alternatives to solving the connection problem posed in premises data communications. To this point our focus has been on only one of these approaches - the empirical techniques use to connect terminals to a 286/386 PC running UNIX/XENIX or some equivalent system. Another alternative is to use a Local Area Network (LAN). The employment of LANs will now be discussed in more detail.

### 8.1 WHY USE LANS?

Previously I made the following statement with regards to a LAN. "This alternative is the approach of choice when one has the freedom and the money to design their premises data communication system starting essentially with a `blank page'." This is a rather glib statement. The question arises as to why it is true?

Go back and take a look at the typical multi-user PC environment with its empirical connection solutions which was shown in Figure 2. Now take a look at the general pictorial of a LAN which is illustrated in Figure 25. The "cloud" represents the connecting media and all supporting protocols. There are many advantages which a LAN has over the data communications approach of Figure 2. I describe several below.

To begin with in Figure 2 one is only dealing with communications between the terminals and the multi-user computer. If there are printers or plotters or other equipment present they are essentially part of another data communications system with the multi-user PC at its center. In contrast as shown in Figure 25 a LAN allows full connectivity of all the data equipments connected to it. The terminals communicate with the computer through it. The computer can communicate with the printer or plotter through it. The terminals can even communicate with each other and with the printer or plotter through it. There is much more flexibility.

This advantage of a LAN in having full connectivity is often described in the context of it allowing peer-to-peer resource sharing.

The typical (UNIX-based) environment shown in Figure 2 does not have peer-to-peer capabilities. Rather, they designate the computers either as "clients" or "servers." A "client" is usually a computer at which a (human) end-user works. A "server" is a computer whose resources (e.g. printers, mass-storage devices, data files, program files, applications software) are available to all (human) end-users. Servers are often more powerful computers than the client computers. In the Figure 2 environment without peer-to-peer resource sharing the computer resources of a client are only available to the (human) end-user stationed at the client.

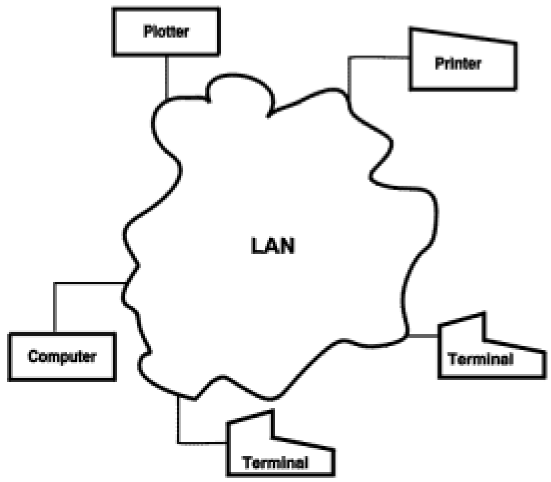



*Figure 26: Data Equipments Connected By a LAN*

However, a LAN has peer-to-peer resource sharing. All networked computers perform both client and server functions. This is the true meaning of full connectivity. It yields one of the major benefits which is file sharing among all the computers.

The multi-user computer system of Figure 2 will generally only make use of a data link level protocol to effect error control. LANs make use of packetization along with the higher levels of the OSI protocol stack. This leads to better error control as viewed from the user interfacing the application.

LANs are inherently faster. Data communications can be carried out at megabit per second (and above) speeds. They can support those applications which are becoming more and more common which need such speeds. Nowhere is this more evident than in the use if computer application packages using high resolution graphics. The multi-user computer system of Figure 2 with its 10’s of KBPS connections to terminals is a "time sharing system." Historically, it handled graphics by using "bit mapping." This was a relatively slow, cumbersome procedure for the UNIX/XENIX software and as a result graphics screens were painted "very slowly." Essentially, it was inappropriate for graphics. Recently, it has been improved by the development of the X-Terminals protocol. This replaces "bit mapping" with the transmission of "drawing descriptives." This makes the multi-user computer somewhat more appropriate for high resolution graphics. Nonetheless, the higher speed LANS have a significant advantage here.

## 8.2 LAN ARCHITECTURES

Work on the development of LANs began in the 1960’s. Since that time many different LAN architectures have been proposed, studied and implemented. However, at the present time only two architectures have survived to be of general interest, the ETHERNET BUS ARCHITECTURE and the TOKEN RING ARCHITECTURE. Neither of these has a clear advantage over the other. It is for that reason that both have been adopted as standards by the

IEEE 802 committee. Other architectures may be of interest in special situations but these two are the only ones worth discussing of general interest. We do this below. Details are taken from [Ref.5] and [Ref. 6].

#### 8.2.1 ETHERNET BUS ARCHITECTURE

This architecture had its origins in work done at XEROX's Palo Alto Research Center (PARC) by Robert Metcalf in the early 1970's. XEROX was later joined by DEC and INTEL in promoting ETHERNET as the coming LAN standard. Basically, Metcalf built upon work done by ARPA (now DARPA) and the University of Hawaii with a multiple access technique called ALOHA.

We can explain the operation of ETHERNET briefly with the aid of Figure 26. Here we see the data equipments which need to communicate all tapping onto transmission media (a cable) which we have labeled "Broadcast Channel-The ETHERNET BUS." The Bus Interface Units (BIUs) provide the essential interfacing between the data equipments and this channel-that is the transmit/receive capability and all needed intelligence. It is an essential feature of ETHERNET that by using the Broadcast Channel any data equipment can transmit to any other data equipment and any data equipment can listen to all transmissions on the channel whether intended for it or for some other data equipment user.

Now how does ETHERNET operate? It makes use of CSMA/CD - this is Carrier Sense Multiple Access/Collision Detection. The ETHERNET BUS - the connecting cable - is passive and can be used for broadcast type transmissions. Consider a specific data equipment unit, a terminal wanting to communicate with the computer. The terminal's BIU before attempting to transmit a data packet onto the ETHERNET BUS first "listens" to determine if the BUS is idle-that is if there are no other packets from other data equipment units on the BUS. It senses the presence of a carrier on the BUS. An active BIU transmits its packet onto the BUS only if the BUS has been sensed idle. If the BUS is sensed busy then the BIU defers its transmission until the BUS becomes idle again. Due to propagation delays and carrier detection time, a collision may occur when a BIU senses an idle BUS and begins to transmit its packet while another data equipment's BIU has already started transmitting a packet that has not yet propagated to this BIU. All BIU's connected to the BUS have some means for "Collision Detection." When a collision occurs, all parties involved cease transmission and wait a random amount of time before initiating retransmission. If collision occurs again this random time wait is repeated but increased and increases at an exponential rate until the collision event disappears. This approach is called " exponential back off."

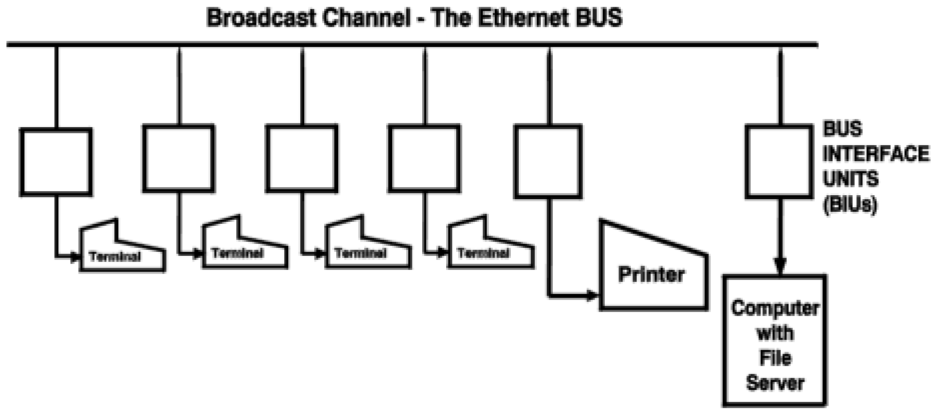



*Figure 27: Ethernet Bus Architecture*

#### 8.2.2 TOKEN RING ARCHITECTURE

This architecture had its origins in work done in Great Britain. Its first known use in the United States was by Prime Computer in 1977. Since that time IBM has adapted this as its preferred LAN architecture.

The operation of the Token Ring Architecture can be explained with the help of Figure 27. In contrast to the ETHERNET BUS the Token Ring structure is a concatenation of point-to-point communications links arranged in a closed loop. Each link is terminated with an active repeater that detects a data packet on the in-bound link and re-transmits it on the outbound link. The detection, regeneration and all intelligence are carried out by the Ring Interface Unit (RIU) which interfaces the data equipment unit to the Ring. Basically, the ring transmission uses a token-passing access scheme. A special packet structure is called the "idle token." This circulates around the ring. When a connected data equipment user wants to transmit a data packet to some other user it may grab the "idle token," change it to a "busy state" and append its data packet to the busy token. At the end of the packet transmission, the data equipment unit issues another idle token. The Token Ring Architecture essentially behaves as a polling system. The most significant factor affecting the ring performance is the ring propagation time, the processing time for token recognition and regeneration at each RIU.

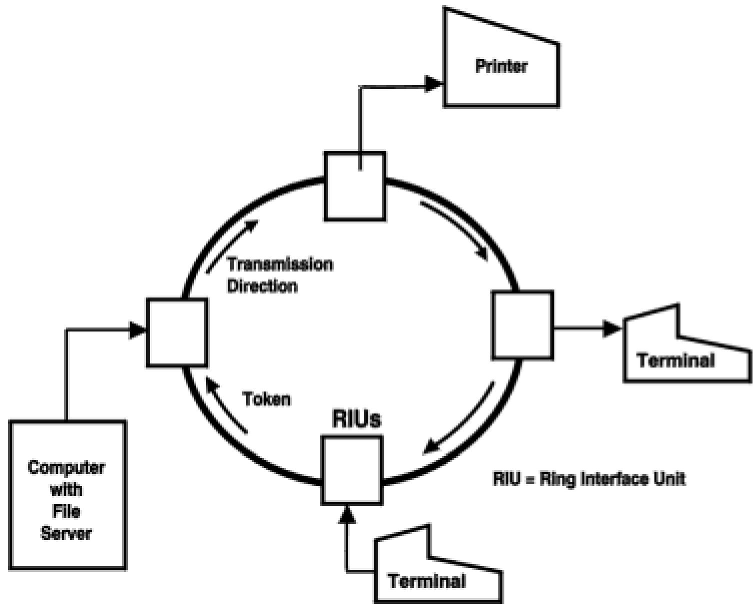



*Figure 28: Token Ring Architecture*

Ring structure is a concatenation of point-to-point communications links arranged in a closed loop. Each link is terminated with an active repeater that detects a data packet on the in-bound link and re-transmits it on the outbound link. The detection, regeneration and all intelligence are carried out by the Ring Interface Unit (RIU) which interfaces the data equipment unit to the Ring. Basically, the ring transmission uses a token-passing access scheme. A special packet structure is called the "idle token." This circulates around the ring. When a connected data equipment user wants to transmit a data packet to some other user it may grab the "idle token," change it to a "busy state" and append its data packet to the busy token. At the end of the packet transmission, the data equipment unit issues another idle token. The Token Ring Architecture essentially behaves as a polling system. The most significant factor affecting the ring performance is the ring propagation time, the processing time for token recognition and regeneration at each RIU.

**8.2.3 COMPARING ETHERNET AND TOKEN RING**

I have said that neither of these architectures has a clear advantage over the other. With ETHERNET the data equipment units do not have to be synchronized, they do not have to control their transmissions. This is a big advantage in implementation. It comes at the cost of collisions. But in lightly loaded networks collisions do not occur that often. Luckily, this is the situation most of the time. In heavily loaded situations, of course, long delays may occur and ETHERNET may degrade significantly. But these heavily loaded situations are almost never seen in the commercial environment.

With Token Ring transmissions are controlled. What is more, the maximum value of delay can be controlled by limiting the amount of time that a data equipment unit can take the idle token out of circulation. One never needs to suffer the infrequent long delays due to collisions that ETHERNET may experience.

Thus, in comparing the two architectures one needs to know where such infrequent long delays are tolerable and where they are not. They most likely are quite tolerable in the ordinary office environment where no catastrophe will result from the delay-just annoyance. Here, we would expect ETHERNET to be quite popular. On the otherhand if the LAN were being used in a factory environment to support process control or some type of automation an occasional long delay may well be catastrophic. Here, we would expect Token Ring to be the preferred architecture.

## 8.3 ETHERNET IMPLEMENTATION

I have noted that both ETHERNET and Token Ring are the LAN architectures which are mostly employed. Yet, to the present date ETHERNET appears to dominate as measured strictly by the amount of ETHERNET equipment in use. This dominance is expected to continue. It will be worth while to describe the evolution of ETHERNET implementations.

The first implementations of ETHERNET employed thick coaxial cable. Termed Thicknet it was defined by the 10 Base 5 standard. Figure 28 provides a pictorial illustration of this type of ETHERNET implementation. By comparing it to Figure 26 you can make the correspondence between the broadcast channel-the ETHERNET BUS and the two coaxial cable segments which are shown as vertical "pipes." Short segments of these pipes are joined by barrel connectors. Long jumps between these pipes required repeaters. The BIU function was carried out by a transceiver which was also referred to as the Media Access Unit (MAU). The Attachment Unit Interface (AUI) connected the data equipment to the MAU.

Thicknet delivered data across the network with a worst case bit error rate of 1 in a 100 million. A LAN implemented by Thicknet was also quite extensive. The maximum network cable length could exceed 8,000 feet. Implementation with Thicknet did require an external transceiver for signaling.

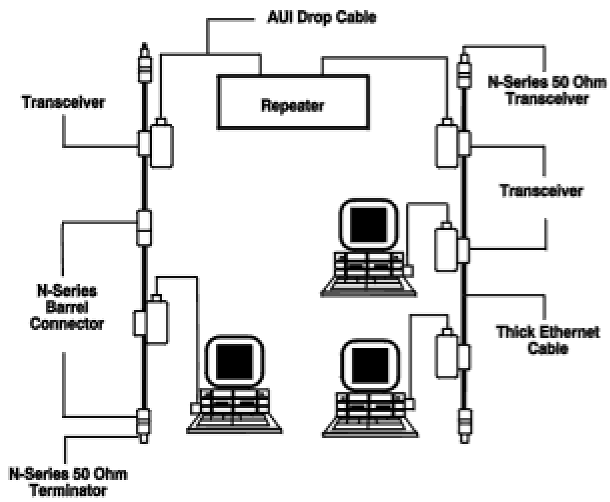



*Figure 29: Thick Ethernet Network*

Unfortunately, the thick coaxial cable was difficult to work with. As a result the second wave implementations of ETHERNET employed thin coaxial cable. Termed Thinnet it was defined by the 10 Base 2 standard. Figure 29 gives a pictorial illustration of this type of ETHERNET implementation. Thinnet had a bit error rate degraded somewhat relative to Thicknet. It also was not as extensive. The maximum network cable length was reduced to be of the order of 3,000 feet. Implementation with Thinnet did not require an external transceiver for signaling. Notice the absence of these in Figure 29.

The Thinnet realization of ETHERNET has recently given way to the use of Unshielded Twisted Pair cable (UTP) under the 10 Base T standard. The use of UTP has given ETHERNET deployments a new burst of growth. The cable used for the connecting medium is the same as that generally (although not always) used as the telephone cable in office buildings for the last 20 years. Thus, ETHERNET under 10 Base T can make use of an existing wiring plant and the task and cost of pulling new cable can be avoided.

ETHERNET under 10 Base T delivers data at the same worst case bit error rate of Thicknet, 1 in 100 million. However, a LAN implemented under 10 Base T has significant distance constraints.The UTP cable length must be of the order of 300 feet at its maximum. Implementation with 10 Base T does not require an external transceiver for signaling unless the adapter card is not 10 Base T compatible.

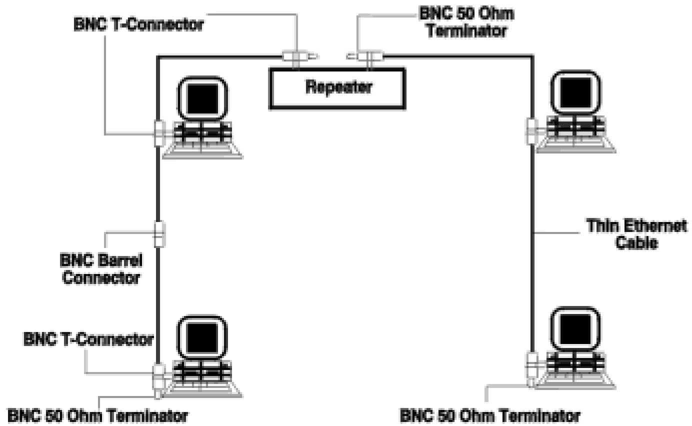



*Figure 30: Thin Ethernet Network*

The topology of an ETHERNET LAN under 10 Base T is also quite different from that of Thicknet and Thinnet. This topology is illustrated in Figure 30 taken from [Ref. 7]. The basic unit of a 10 Base T implementation is called the "Work Group." Data equipments are tied separately by UTP to a Multipoint Repeater or hub. This is a star topology, quite a bit different than the topologies for Thicknet or Thinnet. In fact, it is similar to the Multi-user PC Environment topology of Figure 2. Nonetheless, from a logical point of view this Work Group star topology has the required "Broadcast - ETHERNET BUS" property need for operation. Any data equipment unit can transmit to any other and also "listen" to all transmissions.

While ETHERNET under 10 Base T has the convenience of using UTP it also has the "annoyance" of having to employ 2 wire pairs to tie each data equipment unit to the hub. One pair is needed for transmission and another pair for reception.

The severe distance limitations on the Work Group distance also pose a problem. However, this can be solved by tying Work Groups together. This is indicated at the top of Figure 30. Depending upon the distance, Work Groups can be connected by either 10 Base T, 10 Base 2, 10 Base 5 or even a fiber optic cable.

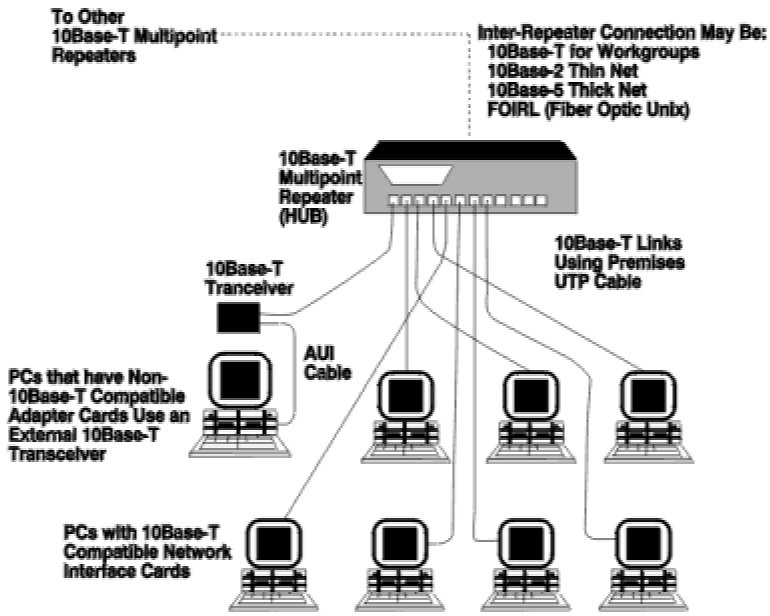



*Figure 31: Ethernet Operating As A 10 Base T Work Group*

Figure 31 illustrates the components needed to connect to an ETHERNET LAN from the point of view of a data equipment unit "user." At the bottom of the figure is the applications software residing in the data equipment unit. This generates and is the ultimate recipient of the data to be communicated across the LAN. "On top of this" is the LAN operating system. Novell is probably the most popular example of this at present. The operating system carries out the packetization of data, complete with addressing. It establishes sessions between communicating data equipments. When collisions are sensed it handles the generation of exponential backoff procedures. "Above" the operating system is the adapter card. This carries out the CSMA/CD procedures. If it detects collisions it passes this information down to the operating system. With Thicknet only an external transceiver or MAU is also required as shown.

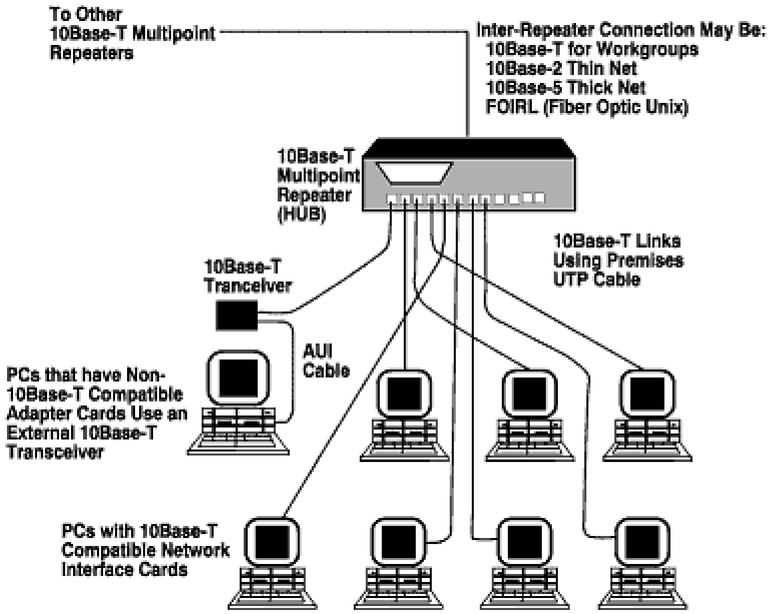



*Figure 32: Connecting To An Ethernet LAN*

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# Glossary

## A

**Acoustic Coupler** - A device that converts digital signals into audio signals, enabling data to be transmitted over the telephone lines via a conventional telephone.

**Active/Passive Device** - A device capable of supplying the current for the loop (active) and a device that must draw its current from connected equipment (passive).

**Address** - A unique sequence of letters or numbers for the location of data or the identity of an intelligent device.

**ANSI (American National Standards Institute)** - The principal standards development body supported by over 1000 trade organizations, professional societies and companies. U.S.A.'s member body to ISO (International Standards Organization.

**ASCII (American Standard Code for Information Interchange)** - A seven-bit-plus parity code established by ANSI to achieve compatibility between data services.

**Asynchronous Transmission** - Transmission is controlled by start and stop bits at the beginning and end of each character.

## B

**Bandwidth** - The range of frequencies available for signalling; the difference expressed in Hertz between the highest and lowest frequencies of a band.

**Baud** - Unit of signalling speed. The speed in baud is the number of discrete conditions or events per second.

**Bell** - AT&T standards for devices that transmit over telephone lines; e.g. modems.

**Bell 212** - An AT&T modem- providing, full duplex, asynchronous, 1,200 bps data transmission for use on the telephone network.

**Bisynchronous Transmission (BSC)** - A byte or character- oriented IBM communications protocol that has become the industry standard. It uses a defined set of control characters for synchronized transmission of binary coded data between stations in a data communications system.

**Bit (Binary Digit)** - The smallest unit of information in a binary system; a 1 or 0 condition.

**Block Check Character** - Used to check transmission accuracy, a character transmitted by the sender after each message block and compared with a block check character computed by the receiver.

**BPS (Bits Per Second)** - Unit of data transmission rate.

**Break- Out Box (BOB)** - A testing device that permits the user to test line conditions.

**Buffer** - A temporary-storage device used to compensate for a difference in data rate and data flow between two devices (typically a computer and a printer); also called a spooler.

**Bus** - A data path shared by many devices (e.g. multipoint line) with one or more conductors for transmitting signals, data or power.

**Byte** - A binary element string functioning as a unit. Eight-bit bytes are most common. Also called a "character".

# C

**Carrier Detect** - Same as Received Line Signal Detector. AN RS-232 modem signal that indicates to an attached terminal that the modem is receiving a signal from a remote modem.

**CCITT (Consultative Committee International Telegraph and Telephone)** - An international association that sets worldwide communications standards (e.g. V.21, V.22, V.22bis).

**Character** - Letter, numerical, punctuation or any other symbol contained in a message.

**Clamping Voltages** - The "sustained" voltage held by a clamp circuit at some desired level.

**Clear To Send (CTS)** - Modem interface signal that indicates to the DTE device to begin transmission.

**Clock -** Timing signals used in synchronous transmission. More generally: the source(s) of timing signals sequencing electronic events.

**Communication Protocol** - The rules governing the exchange of information between devices on a data link.

**Composite Line** - The line or circuit connecting a pair of multiplexors or concentrators.

**Concentrator (Statistical Multiplexor)** - A device used to divide a data channel into two or more channels of lower average speed, dynamically allocating channel space according to demand in order to maximize throughput.

**Conditioning** - The addition of equipment to a leased voice-grade channel, enabling the channel to meet specifications for data transmission.

**Contention** - The facility provided by the dial network or a data PABX which allows multiple terminals to compete on a first come, first-served basis for a number of computer ports.

**CPU (Central Processing Unit)** - Portion of a computer that directs the sequences of operations and initiates the proper commands to the computer for execution.

**CRC (Cycling Redundancy Check)** - An error detection scheme in which the block check character is the remainder after dividing all the serialized bits in a transmission block by a predetermined binary number.

**Crossed Pinning** - Configuration that allows two DTE devices or two DCE devices to communicate.

**Crossover** - Conductor which runs through the cable and connects to a different pin number at each end.

**Crosstalk** - The unwanted transmission of a signal on a channel that interfaces with another adjacent channel.

**CRT (Cathode Ray Tube)** - A television-like picture tube used in a terminal.

**CTS (Clear to Send)** - An RS-232 modem interface control signal which indicates that the attached DTE device is ready for transmission.

# D

**DCE (Data Communications Equipment)** - Devices that provide the functions required to establish, maintain and terminate a data transmission connection; e.g. a modem.

**DDS (Dataphone Digital Service)** - An AT&T communications service in which data is transmitted in digital rather than analog form.

**Demodulation** - The process of retrieving digital (computer) data from a modulated analog (telephone) signal.

**Dial Network** - A network that is shared among many users, any one of whom can establish communication between desired points, when required, by use of a dial or push button telephone.

**Digital Data** - Information transmitted in a coded form (from a computer represented by discrete signal elements.

**Dip Switches** - Switches for opening and closing leads between two devices.

**Downloading** - The process of sending configuration parameters, operating software or related data from a central source to remote stations.

**DSR (Data Set Ready)** - An RS-232 modem interface control signal which indicates tat the terminal is ready for transmission.

**DSU (Digital Service Unit)** - The interface between a user's data DTE device and a digital data service.

**DTE (Data Terminal Equipment)** - Devices acting as data source, data sink, or both (e.g. a terminal).

**DTMF (Data Tone Multiple Frequency) -** The audio signalling frequency on touchtone, push button telephones.

**DTR (Data Terminal Ready)** - An RS-232 modem interface control signal which indicates to the modem that the terminals are ready for transmission.

**Dumb Terminal** - Both hard-copy and VDT type ASCII asynchrounous terminals that do not use a data transmission protocol and usually send data one character at a time.

# E

**EBCDIC (Extended Binary Coded Decimal Interchange Code)** - An eight-bit code used primarily on IBM equipment. The code allows for 256 characters to the sending station for verification of data integrity.

**EIA (Electronic Industries Association)** - A standards organization in the USA specializing in the electrical and functional characteristics of interface equipment.

**EMI/RFI (Electromagnetic Interface/Radio Frequency Interference) Filtering -** Protection from "background noise" that could alter or destroy data transmission.

**Emulation -** The imitation of a computer system, performed by a combination of hardware and software, that allows programs to run between incompatible systems.

**Eprom** - Read-only, non-volatile, semiconductor memory that is erasable via ultra violet light and reprogrammable.

**Even Parity -** A "dumb" terminal data verification method in which each character must have an even number of "on" bits.

# F, G

**FCC** - Federal Communications Commission.

**Firmware** - A computer program or software stored permanently in Prom or Rom.

**Flow Control** - The procedure for regulating the flow of data between two devices; prevents the loss of data once a device's buffer has reached its capacity.

**Frequency-Division Multiplexor (FDM)** - A device that divides the available transmission frequency range into narrower banks, each of which is for a separate channel.

**Frequency Shift Keying (FSK)** - A frequency modulation technique in which one frequency represents a mark and a second, a space.

**Full Duplex (FDX)** - Transmission in either direction, at the same time.

# H, I

**Half Duplex (HDX)** - Transmission in either direction, but not at the same time.

**Handshaking** - Exchange of predetermined signals between two devices establishing a connection.

**Hertz (Hz)** - A measure of frequency or bandwidth. The same as cycles per second.

**Hexadecimal Number System** - The number system with the base of sixteen. In hexadecimal, the first ten digits are 0-9 and the last six digits are the letters A-F.

**IEEE (Institute of Electrical and Electronic Engineers)** - An international professional society that issues its own standards and is a member of ANSI and ISO.

**Interface** - Signal characteristics and meanings of interchanged signals.

# J, K, L

**Joule** - A unit of energy expended when a force of 1 newton (unit of measurement) moves the point of application 1 meter in the direction of the force. (1 watt = 1 joule/sec.)

**Jumper** - A wire which connects a number of pins on one end of a cable only, such a looping back Request to Send (RTS) from Clear to Send (CTS).

**LDM (Limited Distance Modem)** - A signal converter which contains and boosts a digital signal so it may be transmitted much further than a standard RS- 232 signal.

**LED (Light Emitting Diode)** - A semiconductor light source that emits visible light or invisible infrared radiation.

**Leased Line** - A telephone reserved for the exclusive use of leasing customers. Also called a Private Line.

**Line Driver** - A signal converter that conditions a digital signal to ensure reliable transmission over an extended distance.

**Line TurnaroundM** - The reversing of transmission direction from sender to receiver or vice versa when using a half-duplex circuit.

**Local Area Network (LAN)** - A data communications system confined to a limited geographic area with moderate to high data rates (100 Kbps to 50Mbps). The area served may consist of a single building, a cluster of buildings or a campus-type arrangement. The network uses some type of switching technology, and does not use common carrier circuits - although it may have gateways or bridges to other public or private networks.

**Loopback** - Type of diagnostic test in which the transmitted signal is returned to the sending device after passing through all, or a portion of, a data communications link or network.

# M

**Mainframe** - A large-scale computer system that can house comprehensive software and several peripherals.

**Menu** - The list of available software functions for selection by the operator, displayed on the computer screen.

**Modem (Modulator-Demodulator) -** A device used to convert serial digital data from a transmitting terminal to a signal for transmission over a telephone channel, or to reconvert the transmitted signal to serial digital data for acceptance by a receiving terminal.

**Modem Eliminator** - A device used to connect a local terminal and a computer port in lieu of the pair of modems that they would ordinarily connect to.

**Modulation** - Modifying some characteristics of a wave form.

**Multidrop Line** - A single communications circuit that interconnects many stations, each of which contains terminal devices.

**Multiplexor** - A device used for division of a transmission facility into two or more subchannels, either by splitting the frequency band into narrower bands (frequency division) or by allotting a common channel to several different transmitting devices one at a time (time division).

**Multipoint Line** - A single communications line or circuit interconnecting several stations; usually requires a polling mechanism to address each connected terminal.

# N, O, P, Q

**Node** - A point of interconnection to a network. Normally, a point at which a number of terminals are located.

**Null Modem** - A device that connects two DTE devices directly by emulating the physical connections of a DCE device.

**Packet** - A group of bits transmitted as a whole on a packet- switched network.

**Parallel Transmission** - Transmission mode that sends a number of bits simultaneous over separate lines. Usually unidirectional.

**Parity Bit** - A bit that is set at "0" or "1" in a character to ensure that the total number of 1 bits in the data field is even or odd.

**Parity Check** - The addition of noninformation bits that make up a transmission block to ensure tat the total number of 1's is always even or odd.

**Point-to-Point (Link)** - A connection between two, and only two, pieces of equipment. Polling - A means of controlling devices on a multipoint line.

**Private Line** - A telephone line tat does not go through the central office and is reserved for exclusive use of a single customer.

**Protocol** - A formal set of conventions governing the formatting and timing of message exchange between two communicating systems.

**Pulse Dialing** - Older form of phone dialing, utilizing breaks in DC current to indicate the number being dialed.

# R

**RAM (Random Access Memory)** - Semiconductor read-write volatile memory. Data stored is lost if power is turned off.

**Request-to-Send (RTS)** - An RS-232 modem interface signal which indicates that the DTE has data to transmit.

**ROM (Read-Only Memory)** - Nonvolatile semiconductor memory manufactured with predefined data content, permanently stored.

**RS-232** - Interface between data terminal equipment and data communication equipment employing serial binary data interchange.

**RS-423** - Electrical characteristics of unbalanced voltage digital interface circuits.

**RS-449** - General-purpose 37-pin and 9-pin interface for data terminal equipment and data circuit-terminating equipment employing serial binary data interchange.

**RTS (Request-to-Send)** - Physical modem interface control signal from DTE, requesting clearance to transmit.

# S

**SDLC (Synchronous Data Link Control)** - IBM standard protocol superseding BSE.

**Serial Transmission** - The most common transmission mode in which information bits are sent sequentially on a single data channel.

**Shielding** - Protective covering that eliminates electromagnetic and radio frequency interference.

**Short Haul Modem** - A signal converter which Conditions a digital signal to ensure reliable transmission over DC continuous private line metallic circuits without interfering with adjacent pairs in the same cable.

**Simplex Transmission** - Data transmission in one direction only.

**Space -** Absence of signal. In telegraph communications, a space represents the open condition or no current flowing. A space impulse is equivalent to a binary 0.

**Start Bit** - In asynchrounous transmission, the first bit or element in each character, normally a space, which prepares the receiving equipment for the reception and registration of the character.

**Statistical Multiplexor** - A device that allows a single channel to carry information from multiple devices simultaneously.

**Stop Bit** - In asynchrounous transmission, the last bit, used to indicate the end of a character which serves to return the line to this idle state.

**Straight-Through Pinning** - RS-232 and RS-422 configuration that matches DTE to DCE, pin for pin.

**Synchronous Modem** - Modem that carries timing information with data.

**Synchronous Terminal** - A data terminal that operates at a fixed rate with transmitter and receiver in synchronization.

**Synchronous Transmission** - Transmission in which data bits are sent at a fixed rate, with the transmitter and receiver synchronized. Synchronized transmission eliminates the need for start and stop bits.

**Time-Division Multiplexor (TDM)** - A device that accepts multiple channels on a single transmission line by connecting terminals, one at time, at regular intervals-interleaving bits or characters from each terminal.

# T, U, V, W, X, Y, Z

**Time-Sharing** - A method that allows several interactive terminals to use on computer.
Transient - An abrupt change in voltage, of short duration.

**Unbalanced Line** - A transmission line in which the magnitudes of the voltages, on the two conductors are not equal in respect to ground.

**V.35** - CCITT standard governing data transmission at 56 Kbps using 60-108 KHz group band circuits.

**Voice-Grade Line** - A channel that is capable of carrying voice frequency signals.

**Volatile Memory** - A storage medium that loses all data when power is removed.

**Wideband** - A communications channel that has greater bandwidth than voice grade lines.

**X-ON/X-OFF (Transmitter On/Transmitter Off)** - Control characters used for flow control, instructing a terminal to start transmission (X-ON) and end transmission (X-OFF).