

Network Interface

*Chapter 7 & 9 of Data Communications and
Networking, 3rd Edition, Behrouz A. Forouzan
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Review of Physical Layer

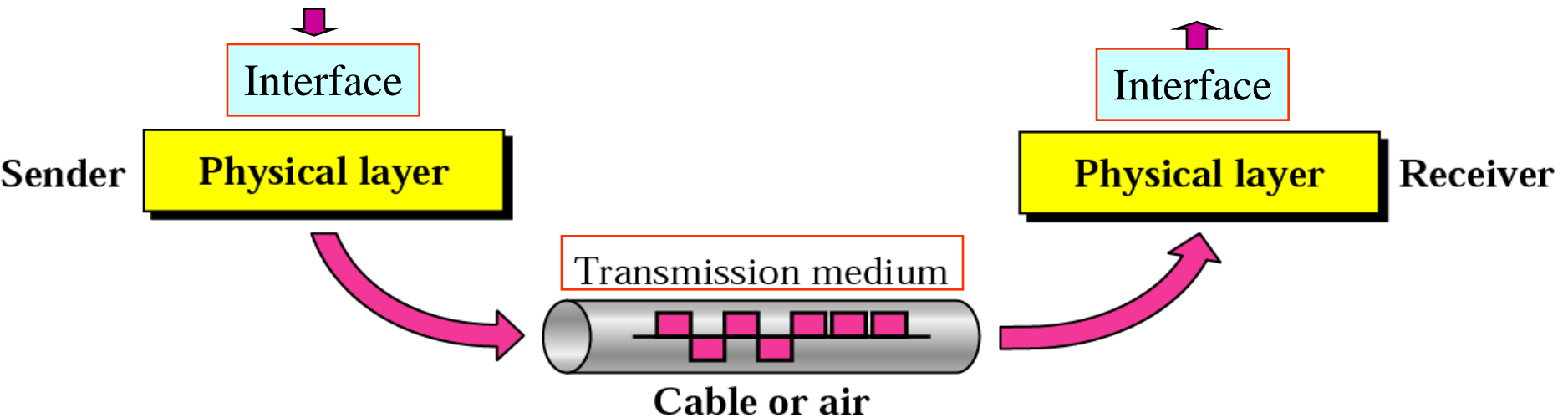
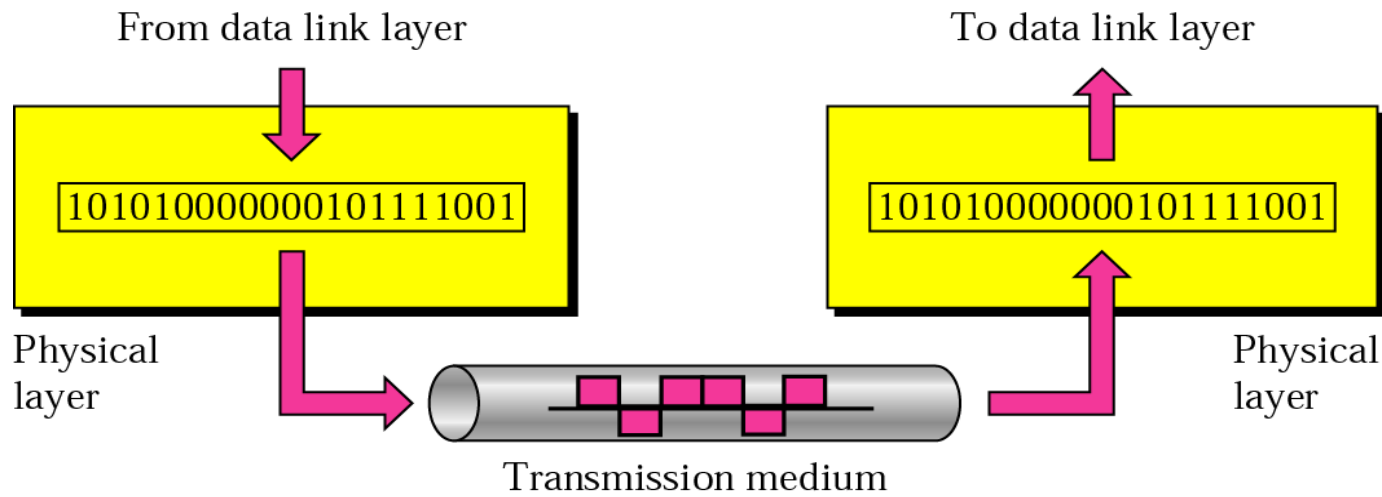


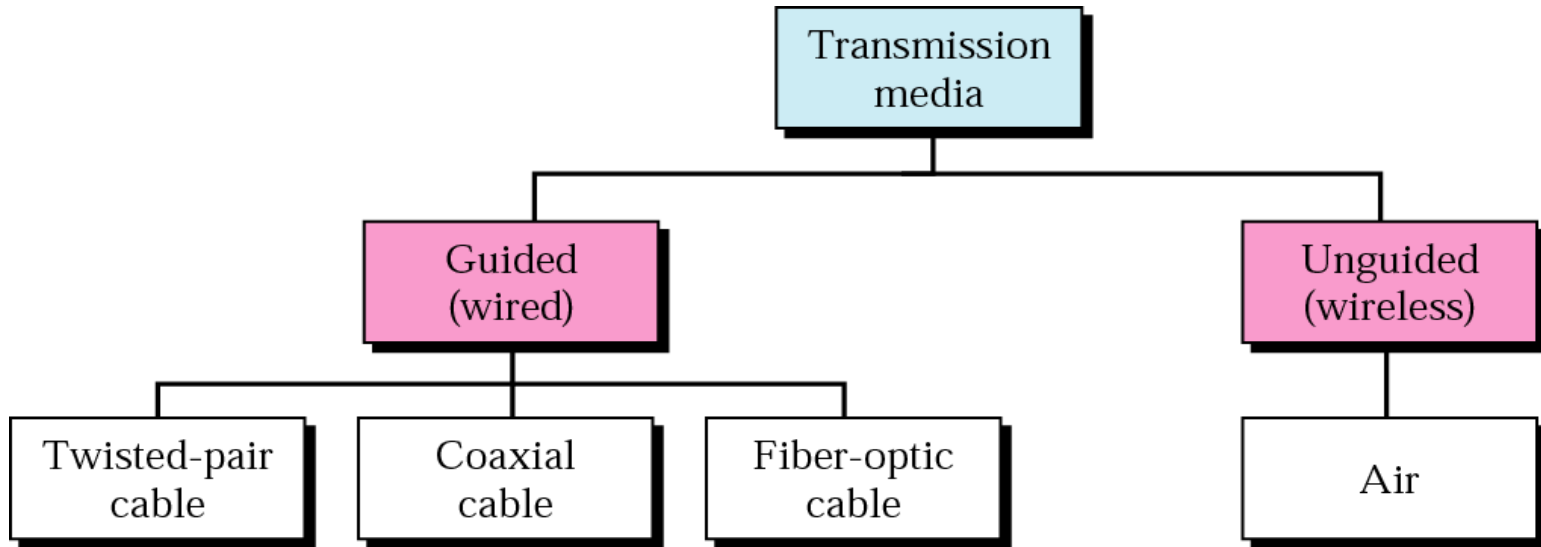
Figure 7.1 Transmission medium and physical Interface

Review of Signals



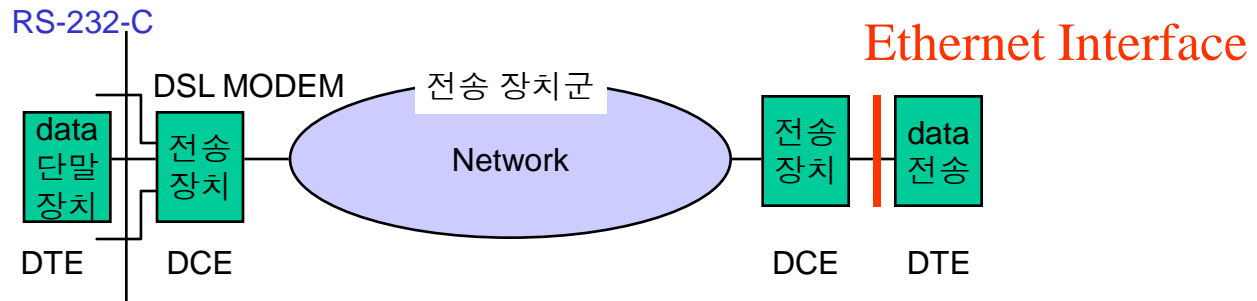
| | <u>Analog signal</u> | <u>Digital signal</u> |
|---------------------|----------------------|--|
| <u>Analog Data</u> | AM, FM | PCM & Video using codecs |
| <u>Digital Data</u> | ASK, FSK, PSK, QAM | LAN Cable Standards (bi-phase, Manchester) |

Review of Transmission Media



- **Medium: the physical matter that carries the transmission.**
 - **With Guided media the transmission flows along a physical guide. The three main types of guided media: twisted pair wiring, coaxial cable and optical fiber cable.**
 - **With Wireless media there is no wave guide and the transmission just flows through the air (or space). The main forms of wireless communications are radio, infrared, microwave, and satellite communications.**

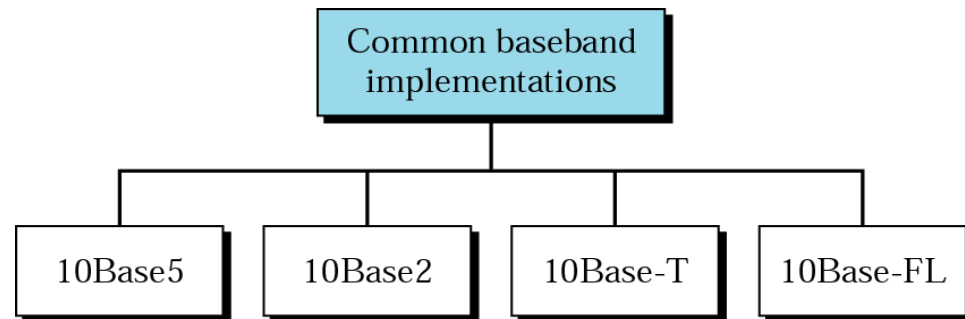
Summary - 통신 인터페이스



- 인터페이스 특성
 - 기계적: **connector** 모양, 치수, 핀의 수
 - 전기적: 전압/전류 레벨, 전압 변동의 **timing (eye diagram)**
 - 기능적: 각 핀의 기능(데이터, 타이밍, 접지)
 - 절차적: 송수신 제어를 위한 절차

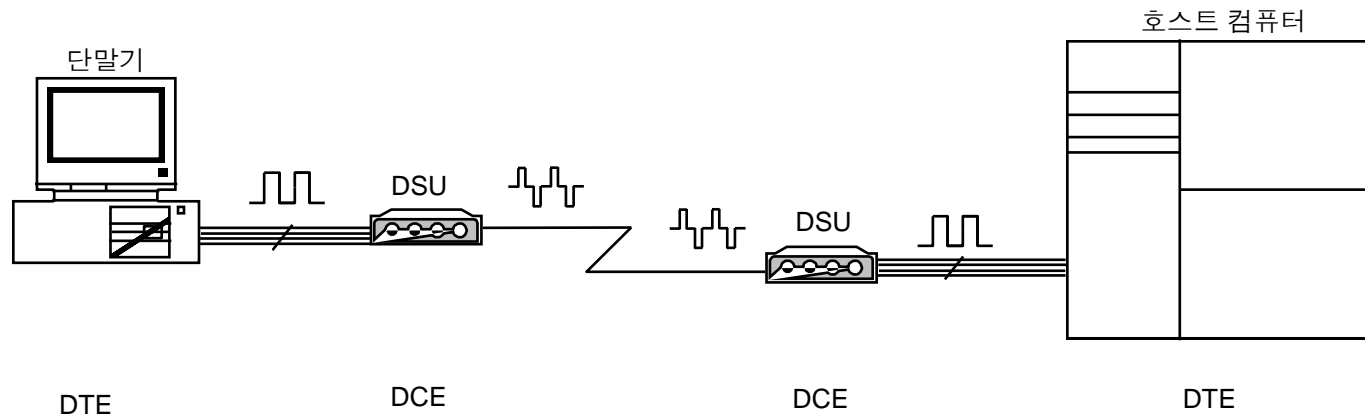
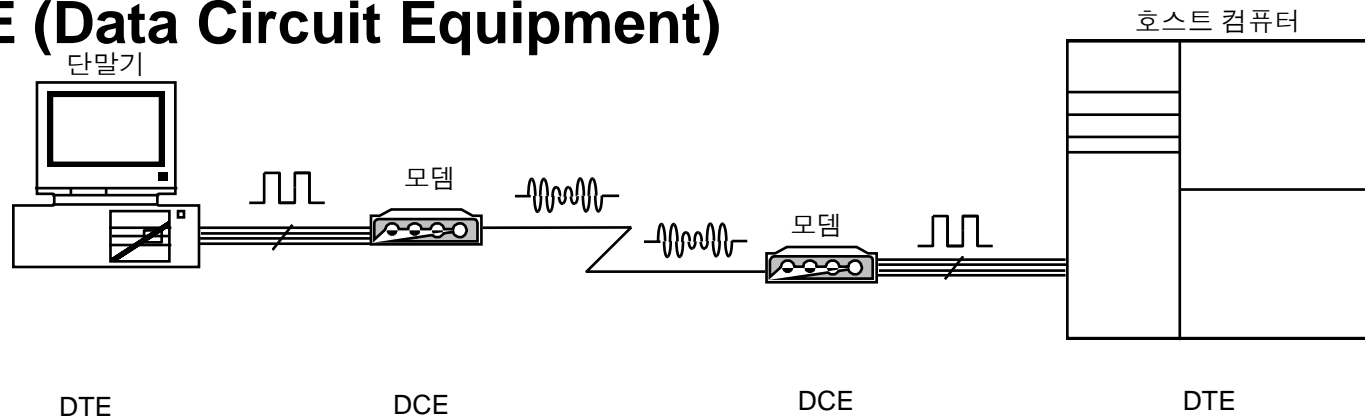
- Ethernet-series

- 10M
- 100M
- 1G
- 10G



Summary - 물리적 접속 규격 (Physical Interface Standards)

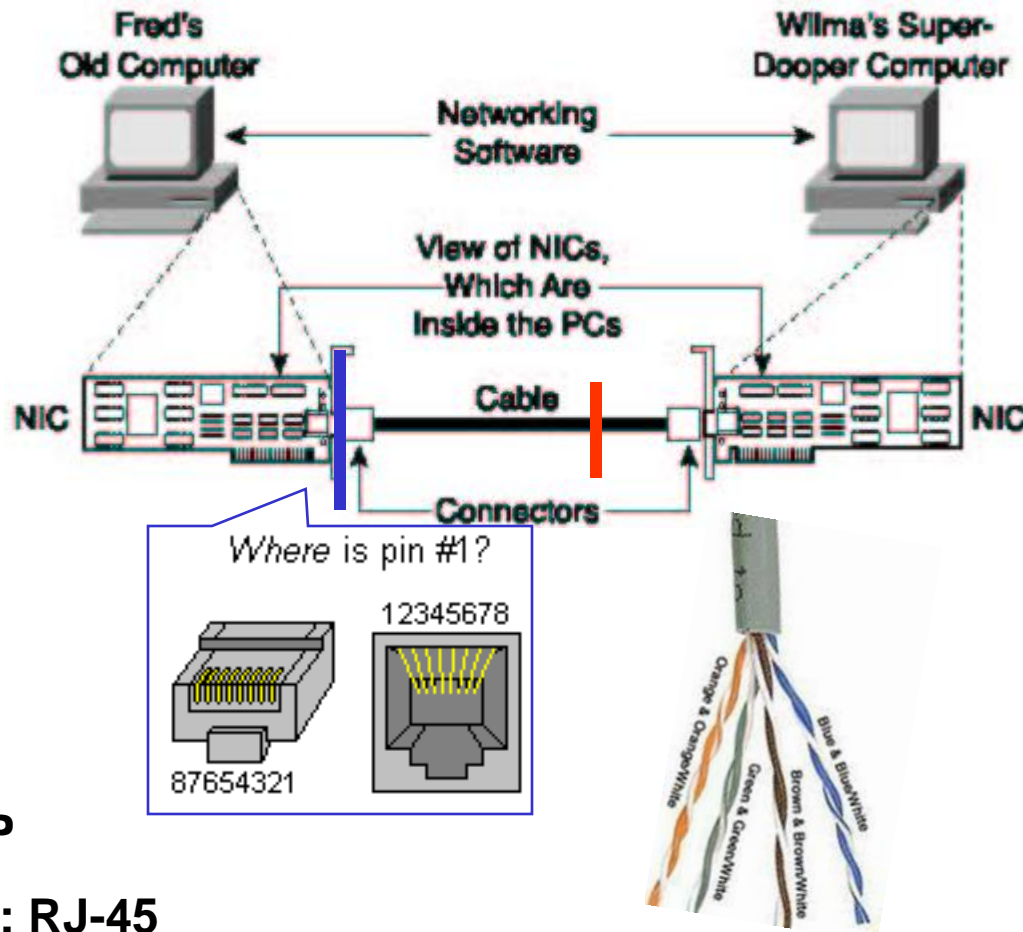
- DTE (Data Terminal Equipment)
- DCE (Data Circuit Equipment)



INTERFACE

- **What is an interface?**
 - The point at which one device connects to another
- **What is an interface standard?**
 - A description which exactly defines the electronic signals required for communication between two devices
- **In data communication, we look at a standard from two perspectives:**
 - DTE - Data Terminal Equipment
 - DCE - Data Circuit-terminating Equipment
 - a.k.a., Data Communications Equipment
- **In Ethernet interface, we look at a network interface w.r.t. peer-to-peer connection**

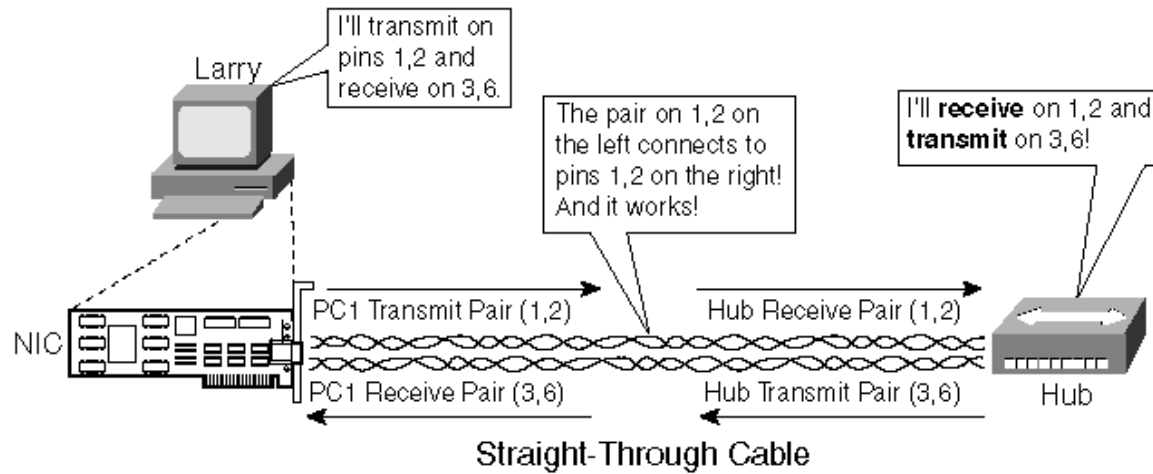
Ethernet LAN interface



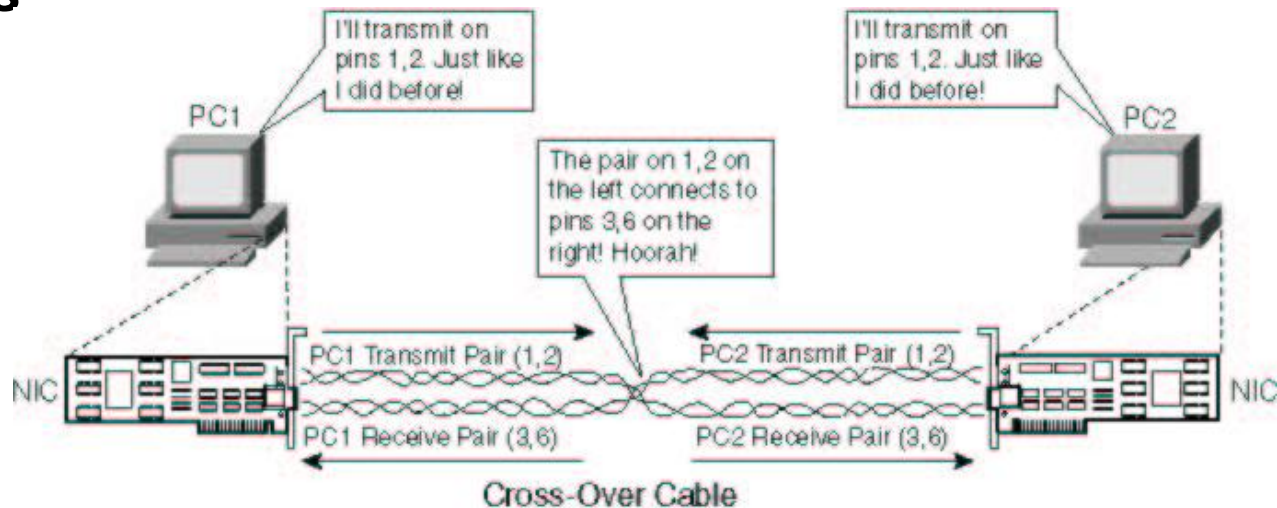
- Cable: UTP
- Connector: RJ-45
- NIC (Network interface card)

LAN의 연결

- direct



- cross



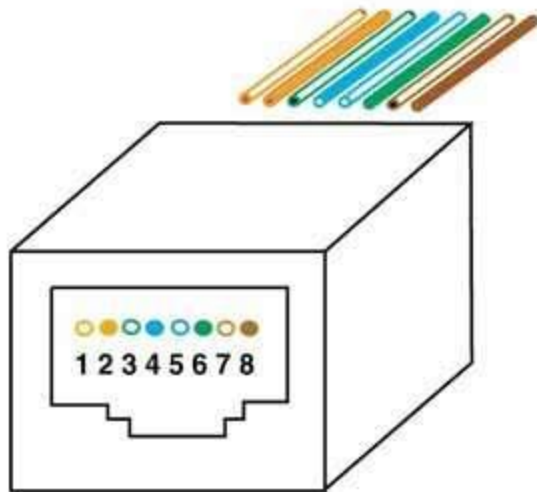
Standard, Straight-Through Wiring (both ends are the same):

What does “straight-through” mean?

What the NIC transmits on pins 1 and 2 gets received by the hub/switch on pins ???

What the NIC receives on pins 3 and 6 gets transmitted by the hub/switch on pins?????

Cat 3 Jack - T568B



So, “transmit” and “receive” are relative to the **NIC**.

The hub/switch has to know to reverse (send on pins 3 and 6; receive on pins 1 and 2)

Standard, Straight-Through Wiring (both ends are the same):









| RJ45 Pin # | Wire Color | Wire Diagram | 10Base-T/100Base-TX Signal |
|------------|---------------------|---|----------------------------|
| 1 | White/Orange |  | Transmit+ |
| 2 | Orange |  | Transmit- |
| 3 | White/Green |  | Receive+ |
| 4 | Blue |  | Unused |
| 5 | White/Blue |  | Unused |
| 6 | Green |  | Receive- |
| 7 | White/Brown |  | Unused |
| 8 | Brown |  | Unused |

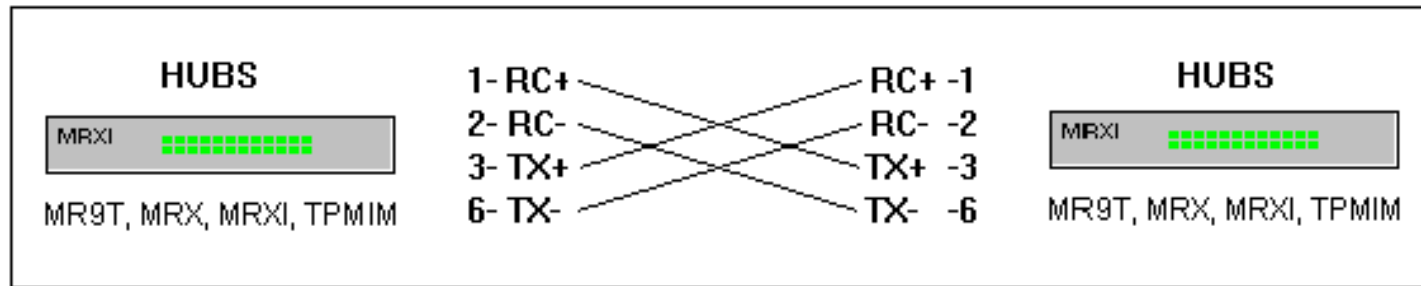
Table 1 - Straight-Through Cable Pinout

Crossover cables

What if we want to connect two hubs together, or two switches together, or a hub and a switch?














A hub is expecting to send on pins 3 and 6 but the other device is expecting to receive on pins 1 and 2.

Solution?



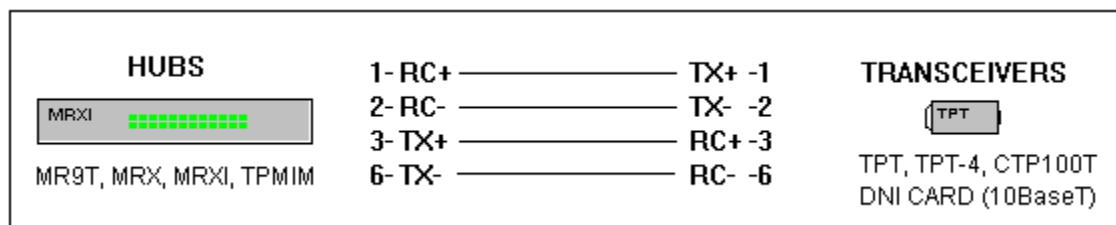
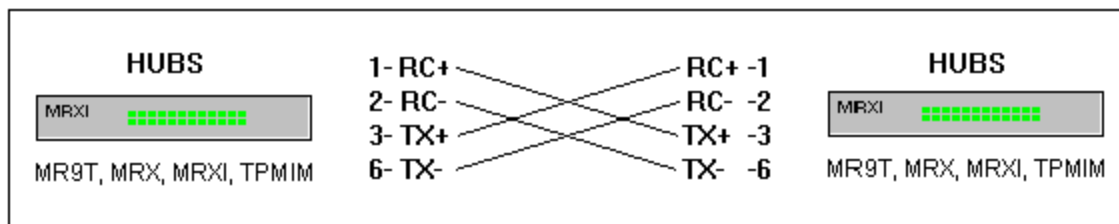
A “crossover” cable, with ends pinned out differently

Cross-over Wiring (some wires are crossed to different pins):

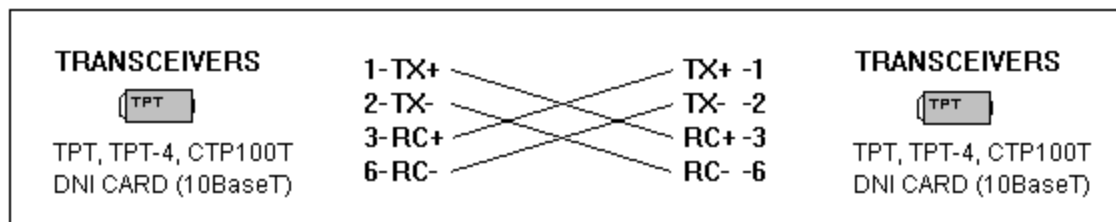
| End 1 | | | End 2 | | |
|-------|--------------|---|-------|--------------|---|
| 1 | White/orange |  | 1 | White/green |  |
| 2 | Orange |  | 2 | Green |  |
| 3 | White/green |  | 3 | White/orange |  |
| 4 | Blue |  | 4 | Blue |  |
| 5 | White/blue |  | 5 | White/blue |  |
| 6 | Green |  | 6 | Orange |  |
| 7 | White/brown |  | 7 | White/brown |  |
| 8 | Brown |  | 8 | Brown |  |

Straight-through vs. Crossover

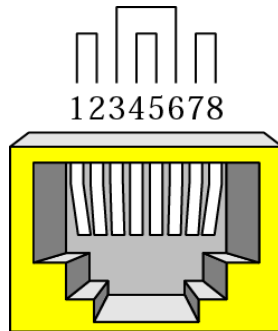
Hubs
implies
switches
also



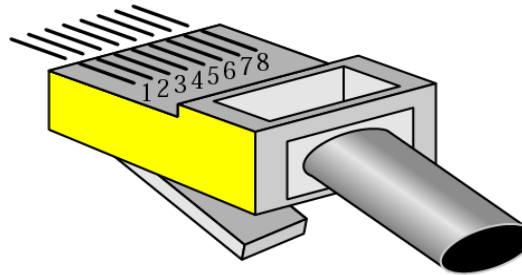
DNI:
“Desktop
Network
Interface”
(aka NIC)



Examples - *Physical Interface*



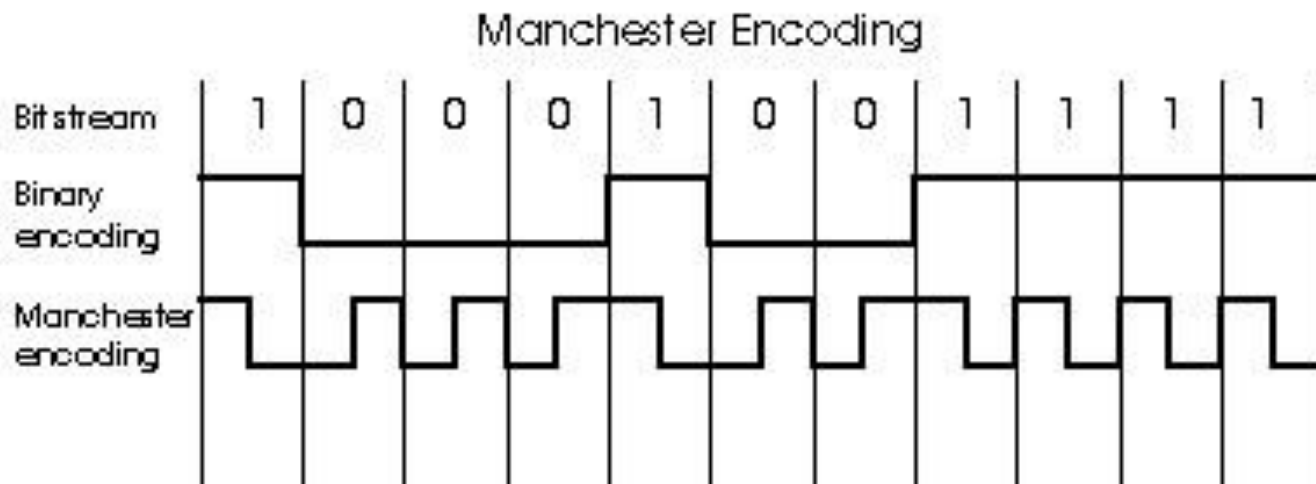
RJ-45 Female



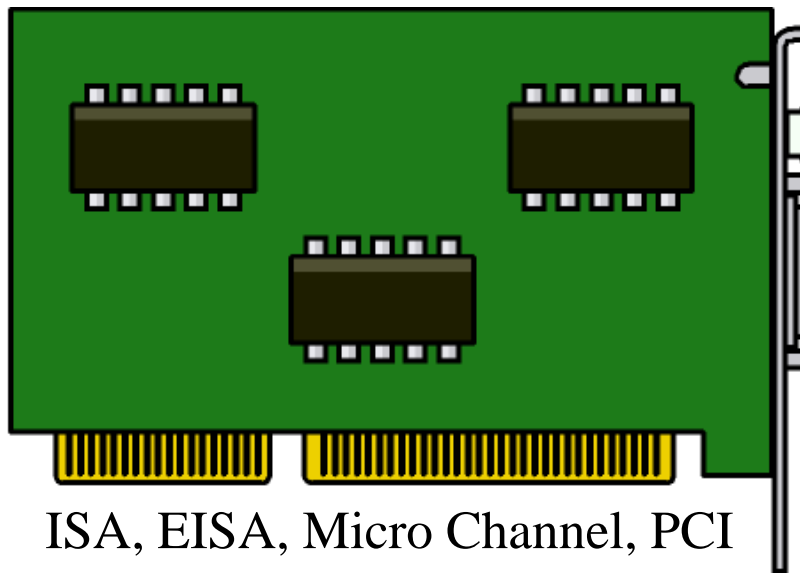
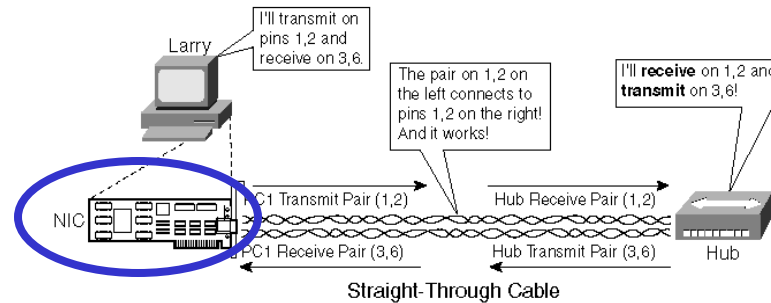
RJ-45 Male

Line encoding

- LAN encoding is **Manchester encoding** –see next
 - Each bit has a transition



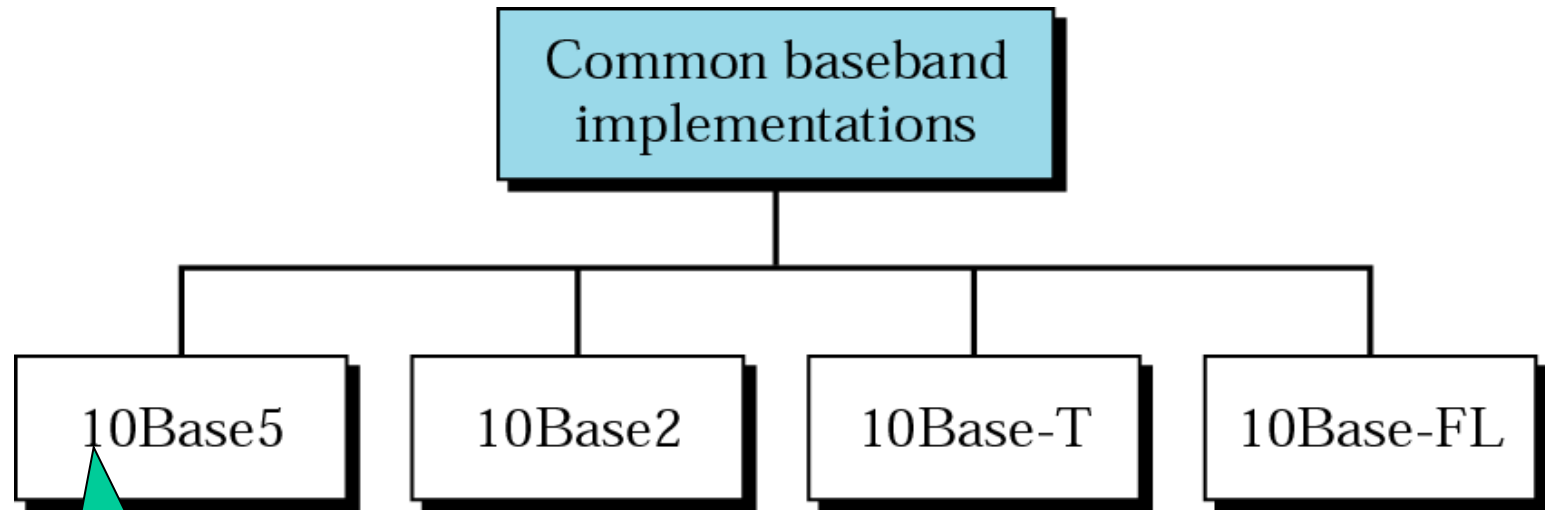
Network Interface Card (NIC)



- Ethernet – 10Mbps
- Fast Ethernet - 100Mbps
 - 100BaseT
- Giga Ethernet – 1Gbps
- 10Giga Ethernet – 10Gbps

The 10Mb/s Ethernet Standard

IEEE 802.3



Different
physical layer
options

10Base-5: Original Ethernet: large thick coaxial cable.

10Base-2: Thin coaxial cable version.

10Base-T: Voice-grade unshielded twisted-pair
Category-3 telephone cable.

10Base-F: Two optical fibers in a single cable.

The 100Mb/s Ethernet Standard

"Fast Ethernet"

Different physical layer options

Ethernet MAC Protocol

100Base-T4

100Base-TX

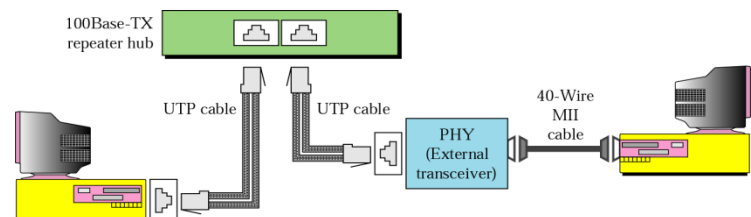
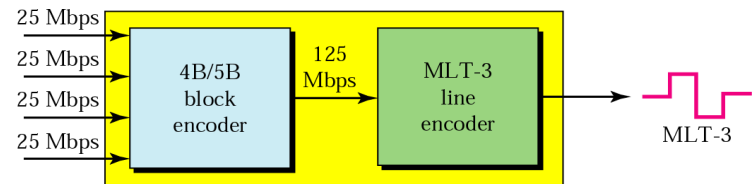
100Base-FX

Up to 100m of cable per segment.

100Base-T4: Uses four pairs of voice grade Category-3 cable.

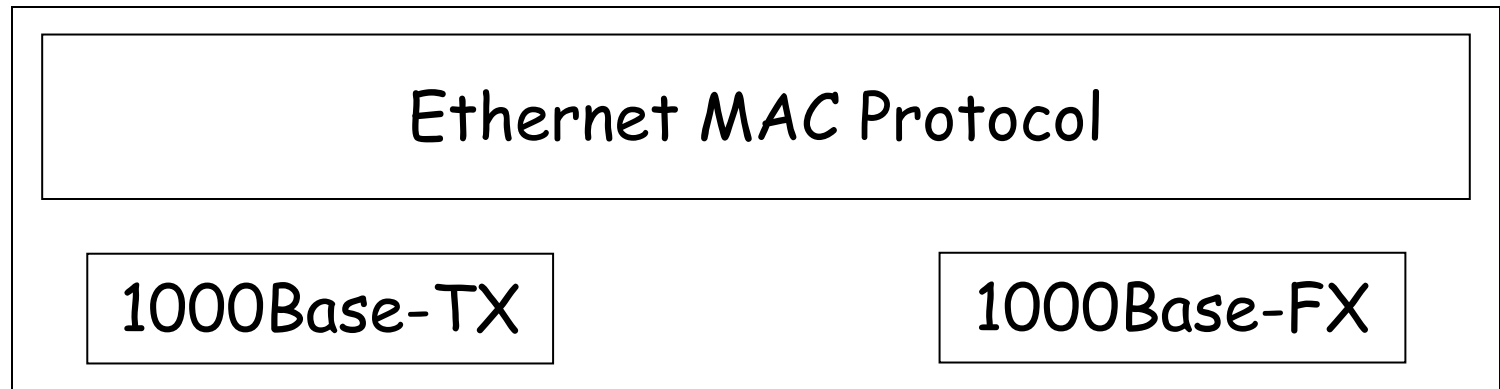
100Base-TX: Uses two pairs of data grade Category-5 cable.

100Base-FX: Uses two optical fibers.



The 1Gb/s Ethernet Standard

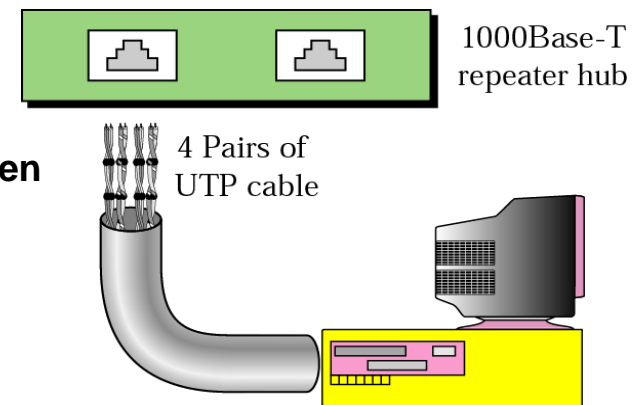
"Gigabit Ethernet"



1000Base-TX: Uses four pairs of data grade Category-5 cable.

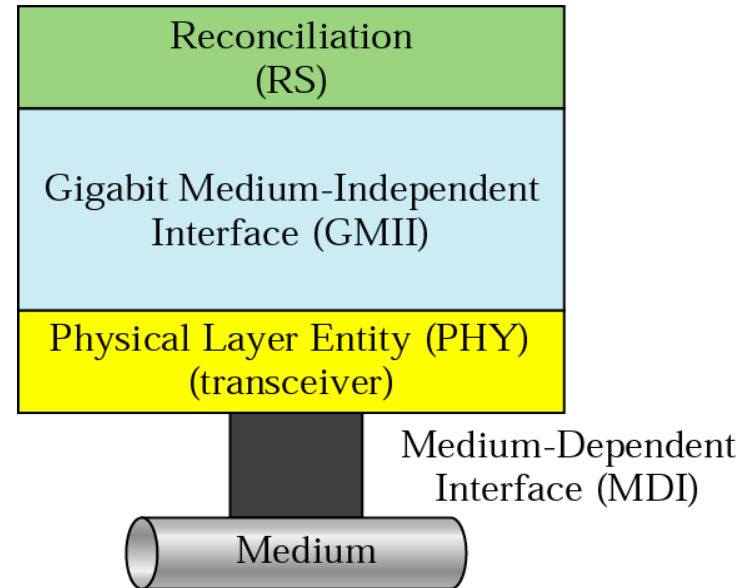
1000Base-FX: Uses two optical fibers.

- use standard Ethernet frame format
- in shared mode, CSMA/CD is used; short distances between nodes to be efficient
- uses hubs, called here "Buffered Distributors"
- Full-Duplex at 1 Gbps for **point-to-point links**
- 10 Gbps now !

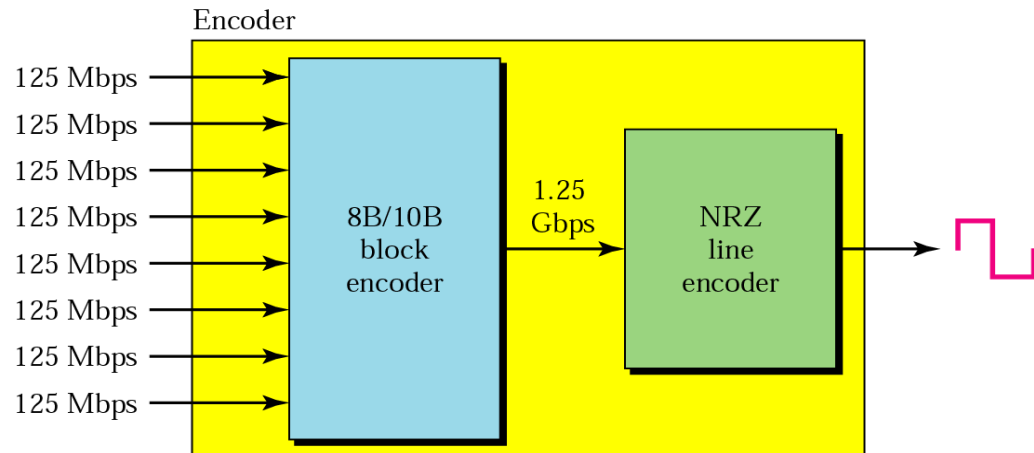


1 Gigabit Ethernet

- **Protocol Stack**

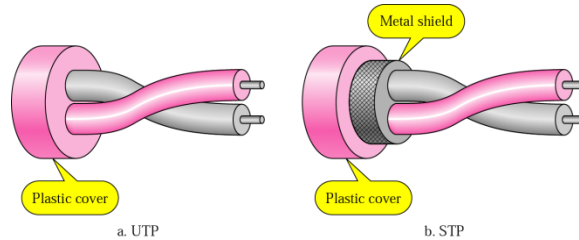


- **Line Coding**



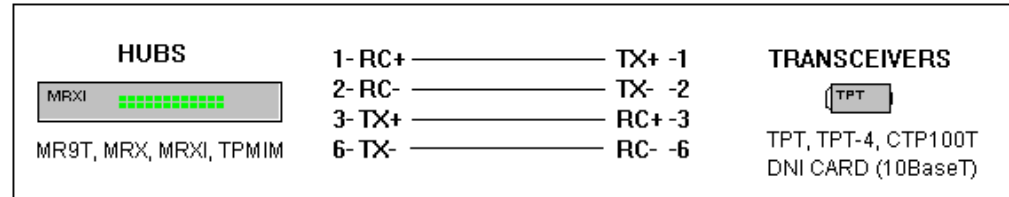
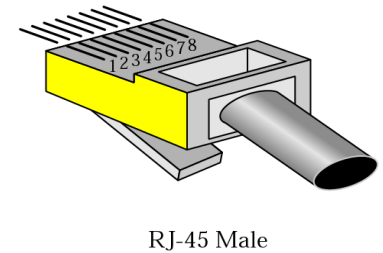
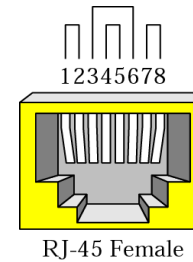
Summary –Ethernet Interface

- **Cable: UTP**

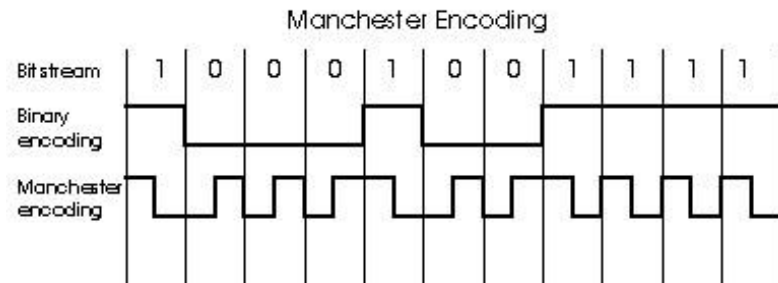


- **Connector: RJ-45**

- **NIC (Network interface card)**



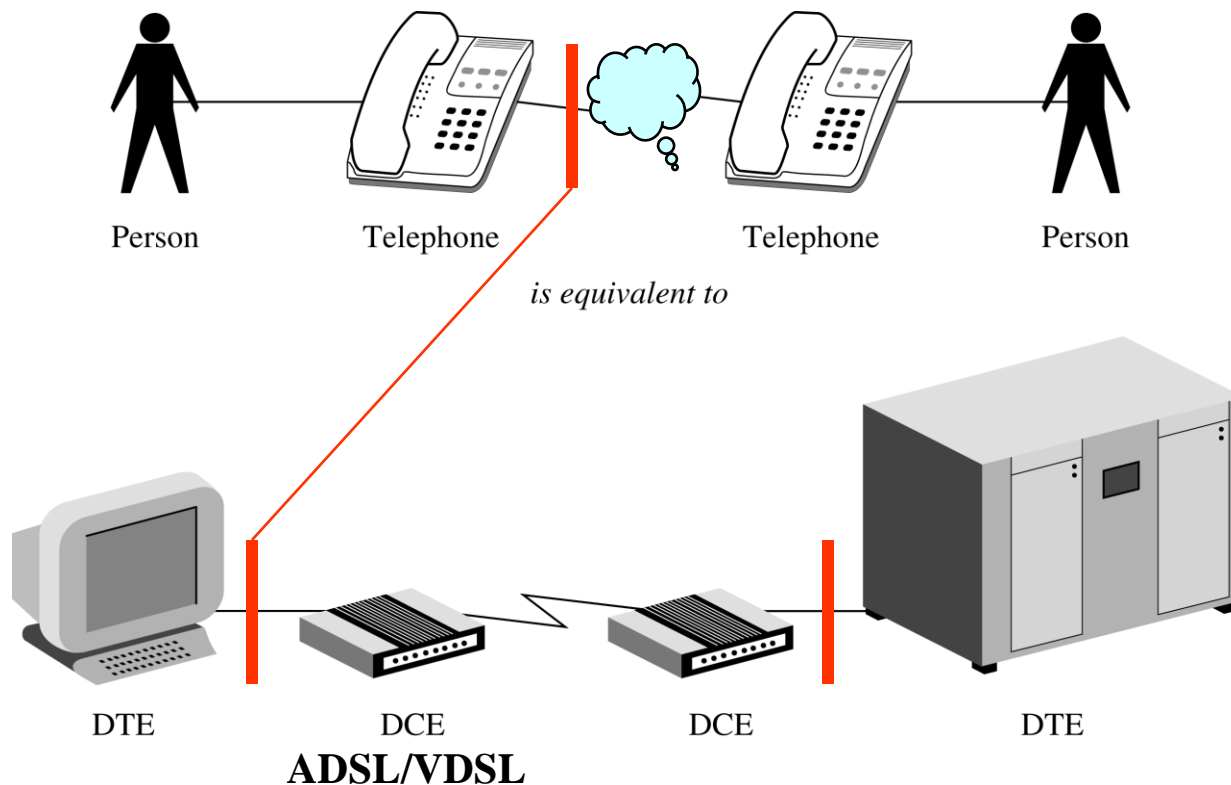
- **LAN encoding is Manchester**



Telephone Interface

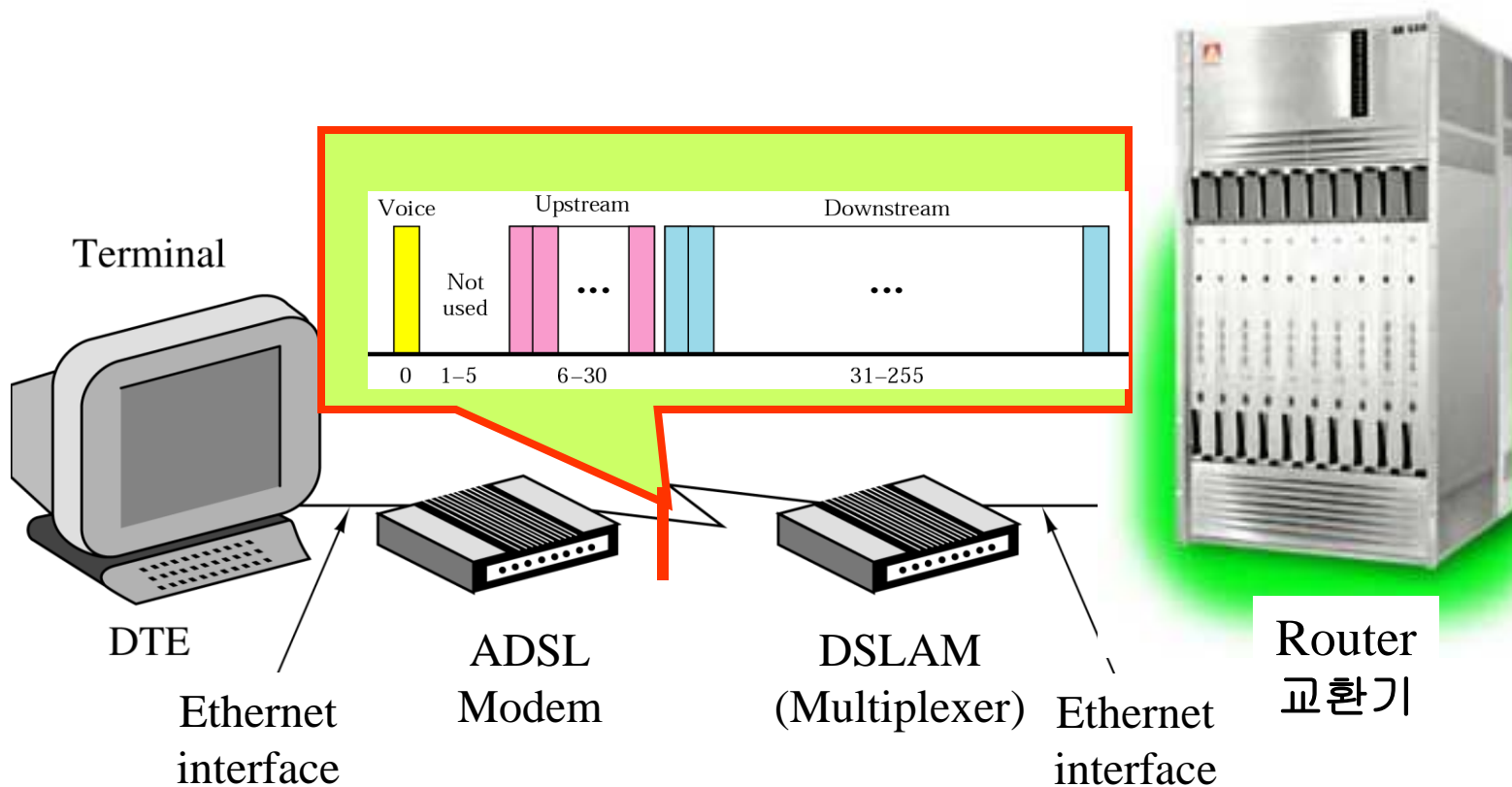
- Digital Interfaces (DTE to DCE)
 - Focus on RS-232-C

DTEs AND DCEs



DSL Technology

- *Digital Subscriber line (DSL) is one of the most promising for supporting high-speed digital communication over **the existing telephone lines**.*



ADSL Technology

- *ADSL is an asymmetric communication technology designed for residential users; it is not suitable for businesses.*
- *ADSL is an adaptive technology. The system uses a data rate based on the condition of the local loop line.*

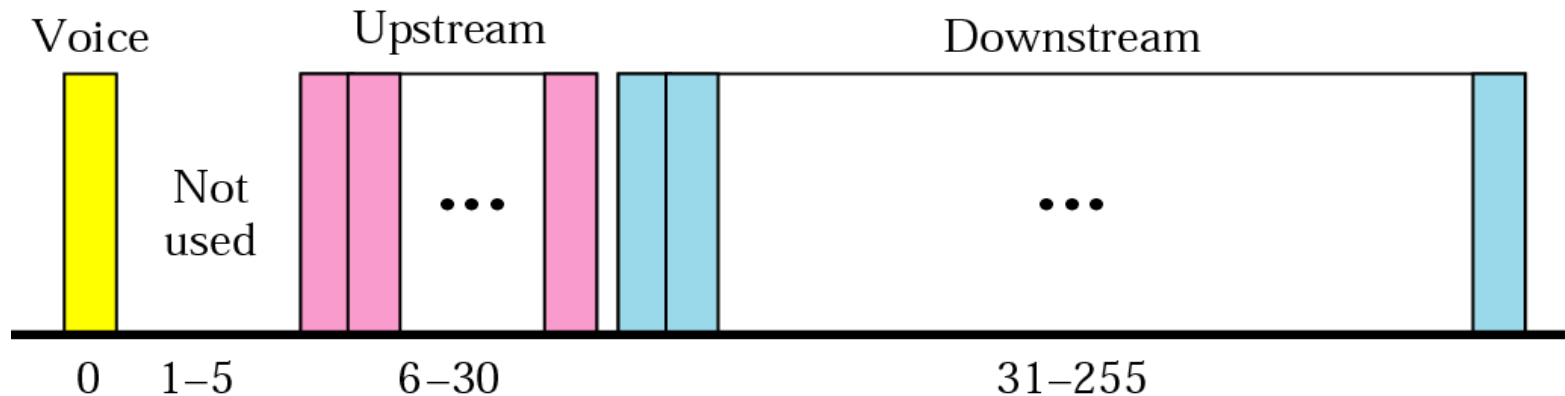


Figure 9.2 *Bandwidth division*

DMT Technology

- *The existing local loops can handle bandwidths up to 1.1 MHz.*
- *Discrete multitone technique (DMT) combines QAM and FDM. ($1.104\text{MHz} = 256 * 4.312\text{ KHz}$)*

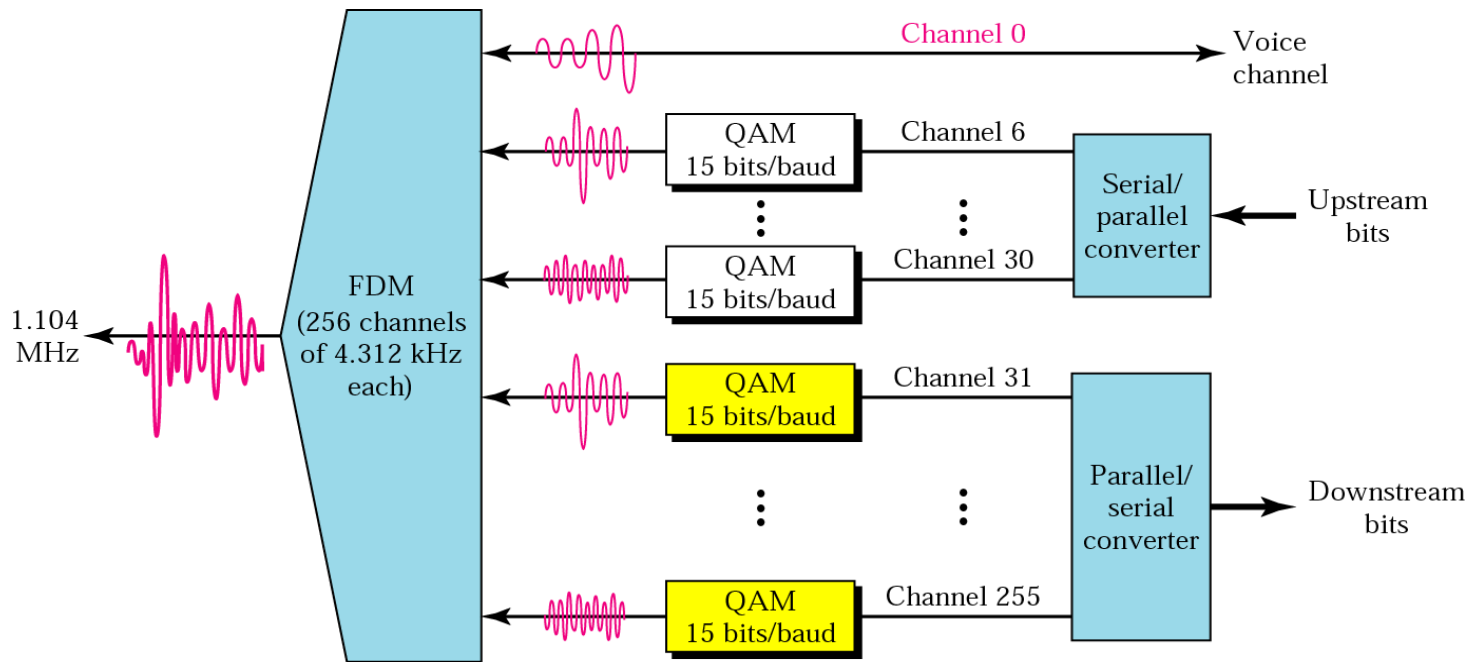
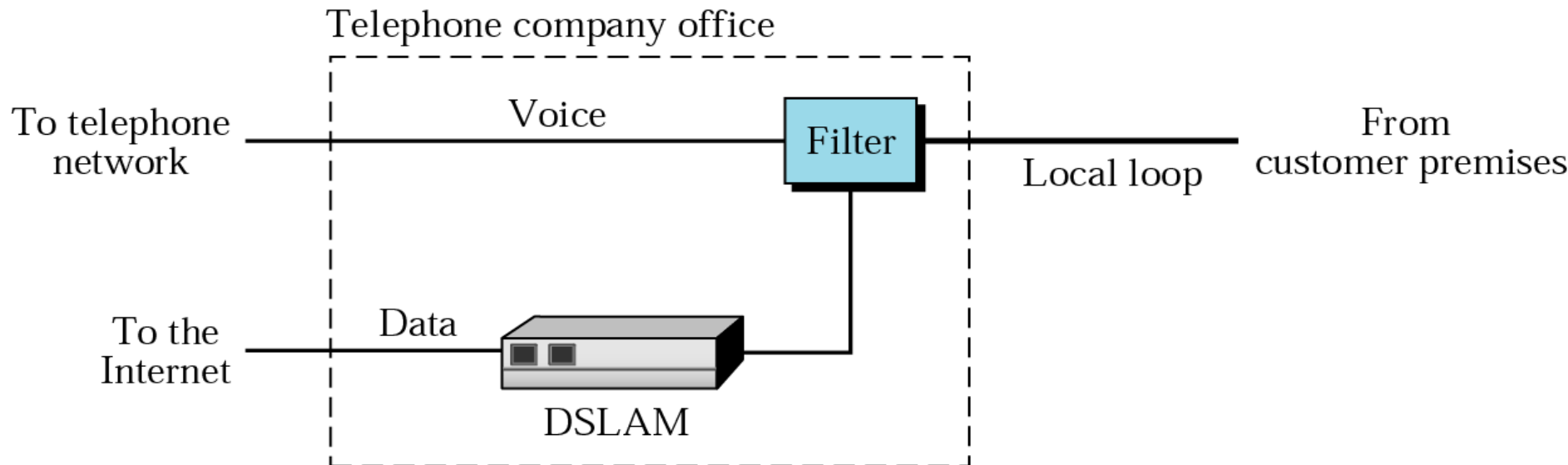
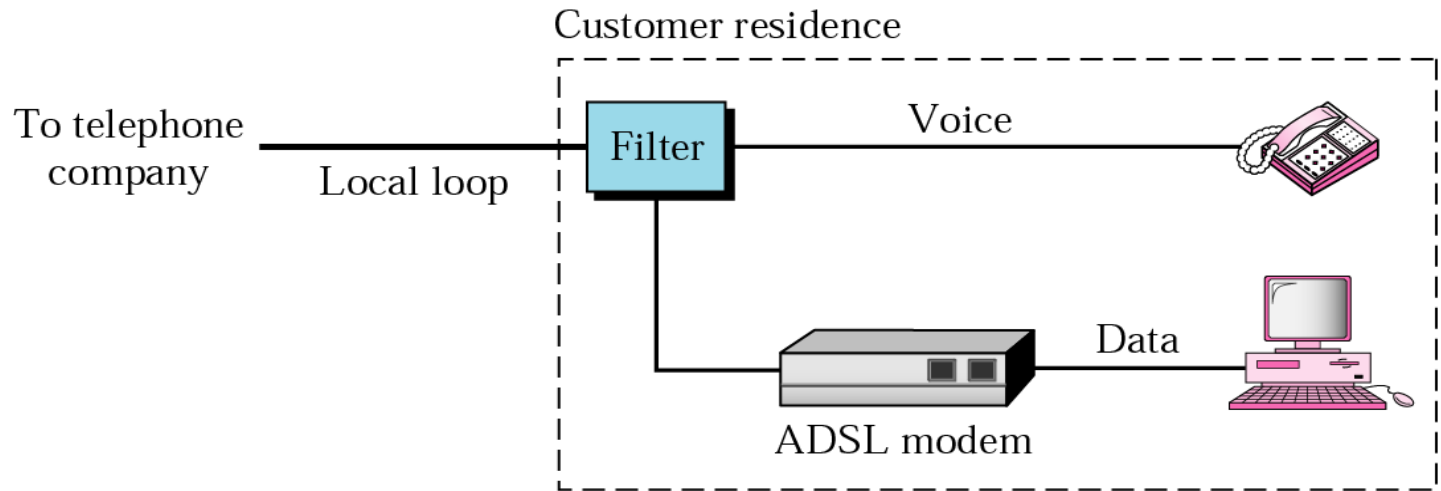
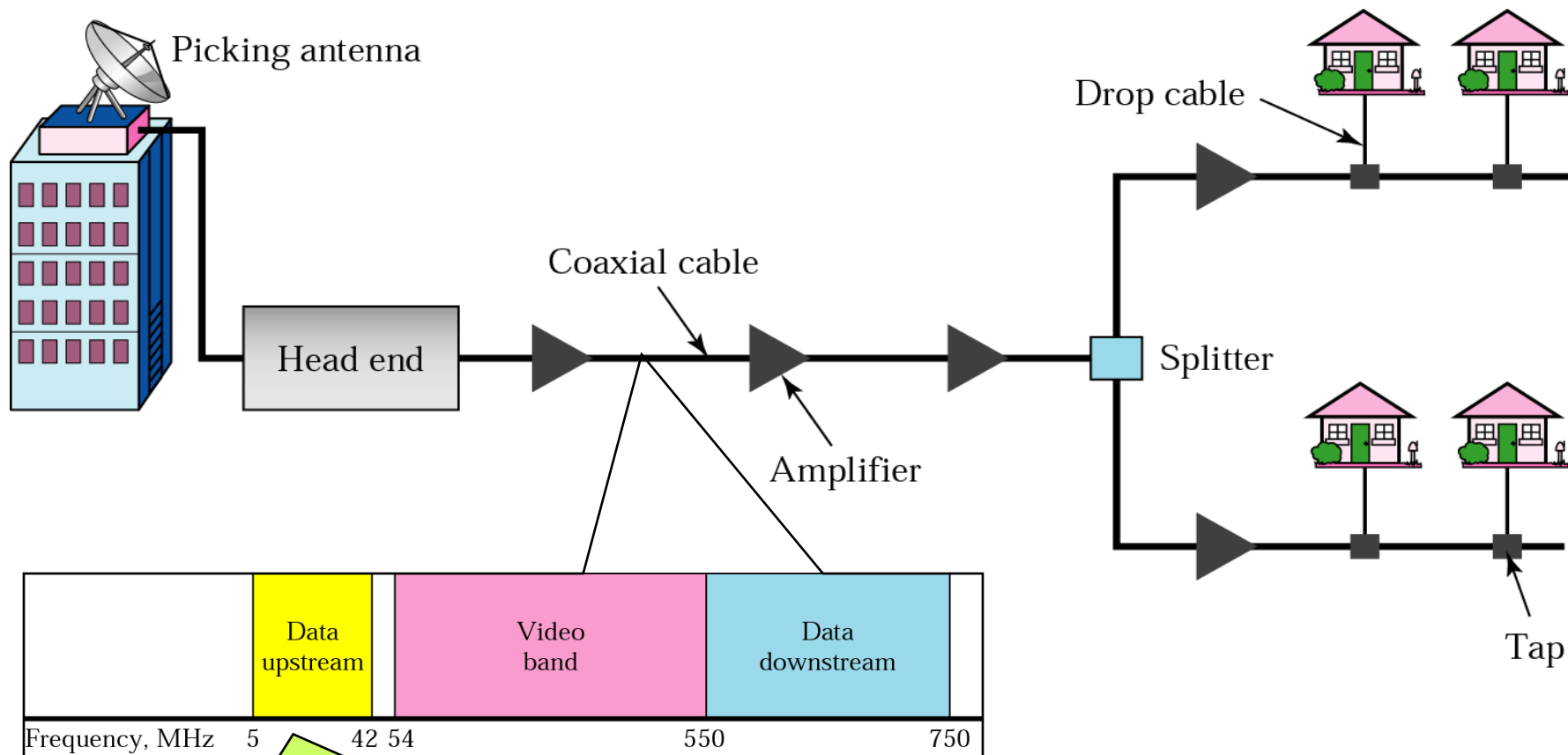


Figure 9.3 *ADSL modem & DSLAM*

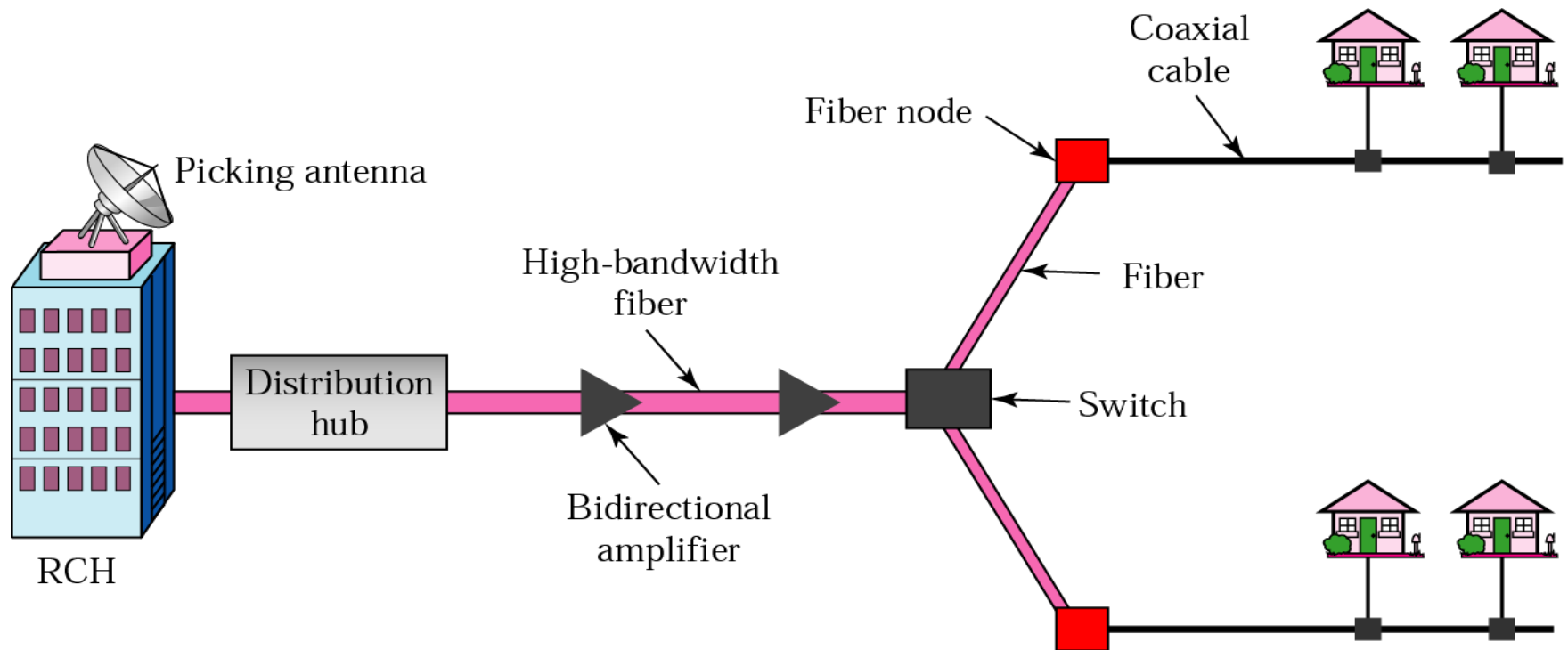


Traditional Cable Networks



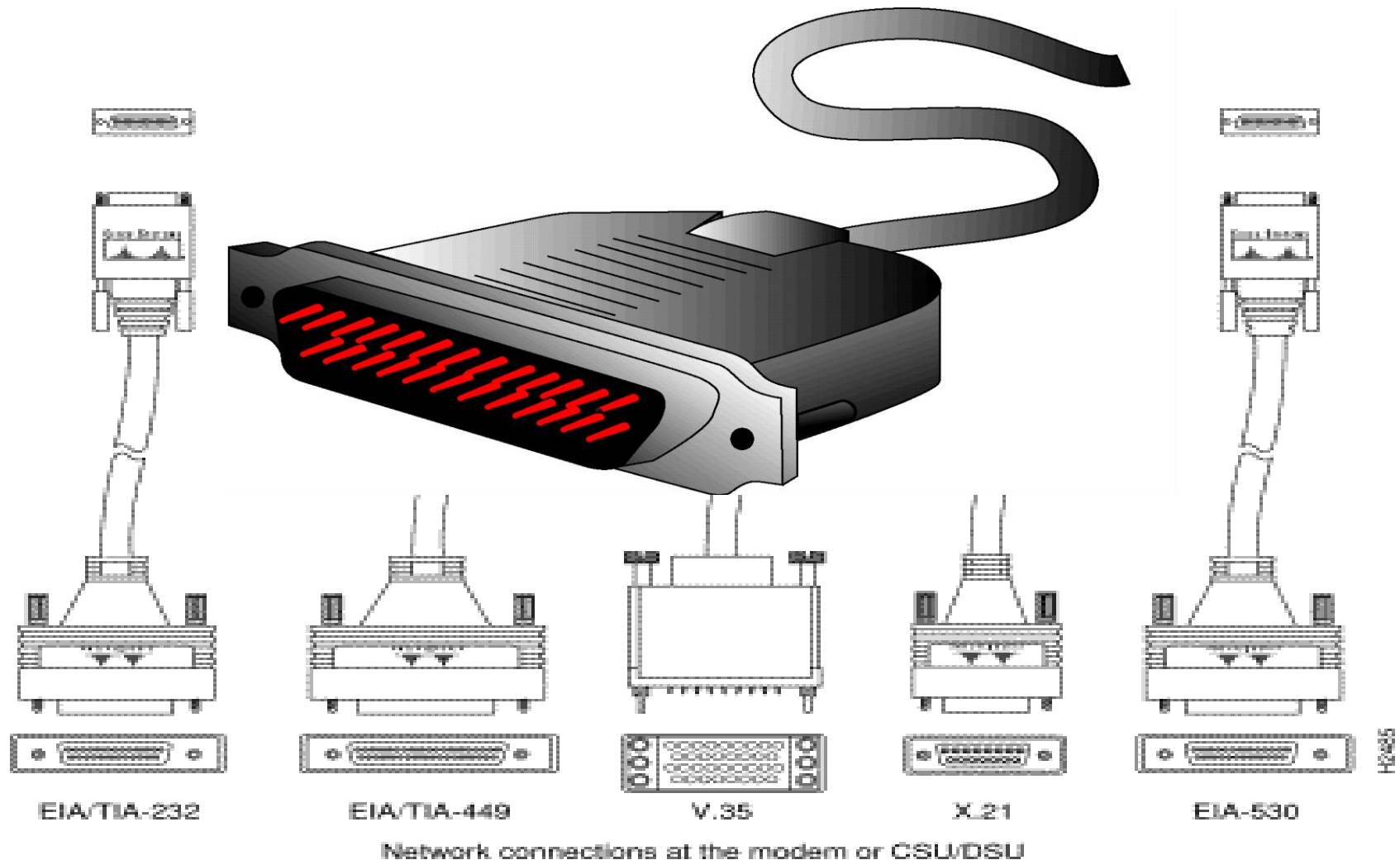
Downstream data are modulated using the 64-QAM modulation technique. The theoretical downstream data rate is 30 Mbps. Upstream data are modulated using the QPSK modulation technique. The theoretical upstream data rate is 12 Mbps

Figure 9.6 *HFC network*



Examples - *Physical Interface*

Figure 2-15: Serial Interface Adapter Cables



Characteristics of Interface

- **Mechanical** **ISO 2110**
 - Connection plugs
- **Electrical** **V.28**
 - Voltage, timing, encoding
- **Functional** **V.24**
 - Data, control, timing, grounding
- **Procedural** **V.24**
 - Sequence of events

Some organisations concerned with standards:

- **EIA - Electronic Industries Association (RS-232)**
- **IEEE - Institute of Electrical and Electronic Engineers (IEEE 488-1978 parallel interface standard.)**

RS232 – Characteristics continued

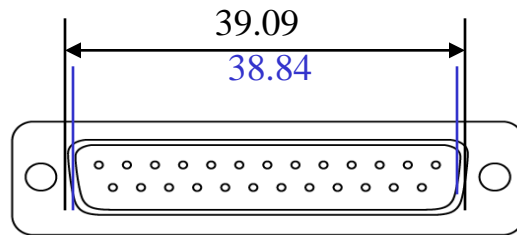
- ****DTE** - Data terminal equipment PC (i.e., male connector 9-pin)
- **DCE** - Data communication equipment MPSU (i.e., female connector 9-pin)
- Serial data standards defined as RS-232C/D are as follows

Mode - single-ended

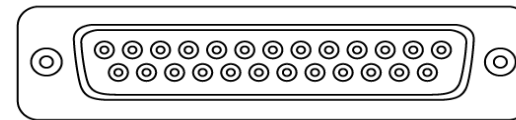
- **Max. number of drivers** 1
- **Max. number of receivers** 1
- **Max. cable length** 15m
- **Max. data rates bits/s** 20k
- **Transmit levels** 5 V min 15 V max.
- **Receive sensitivity** 3V
- **Load impedance** 3k to 7k
- **Output current limit** 500mA to Vcc or gnd
- **Driver Zout min** (pwr off) 300Ω

Mechanical Specification

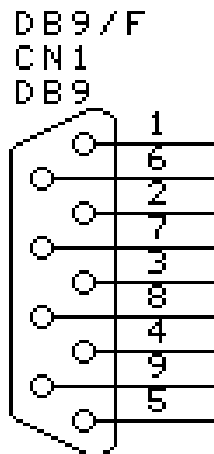
FIGURE 4-4: THE DB25 CONNECTORS (*ISO Standard 2110*) 25-wire cable, 50 feet (15meter)



DB25 male connector



DB25 female connector



Electrical Specification

Data - NRZ-L encoding

Control signal - NRZ-L encoding (-3,+3)

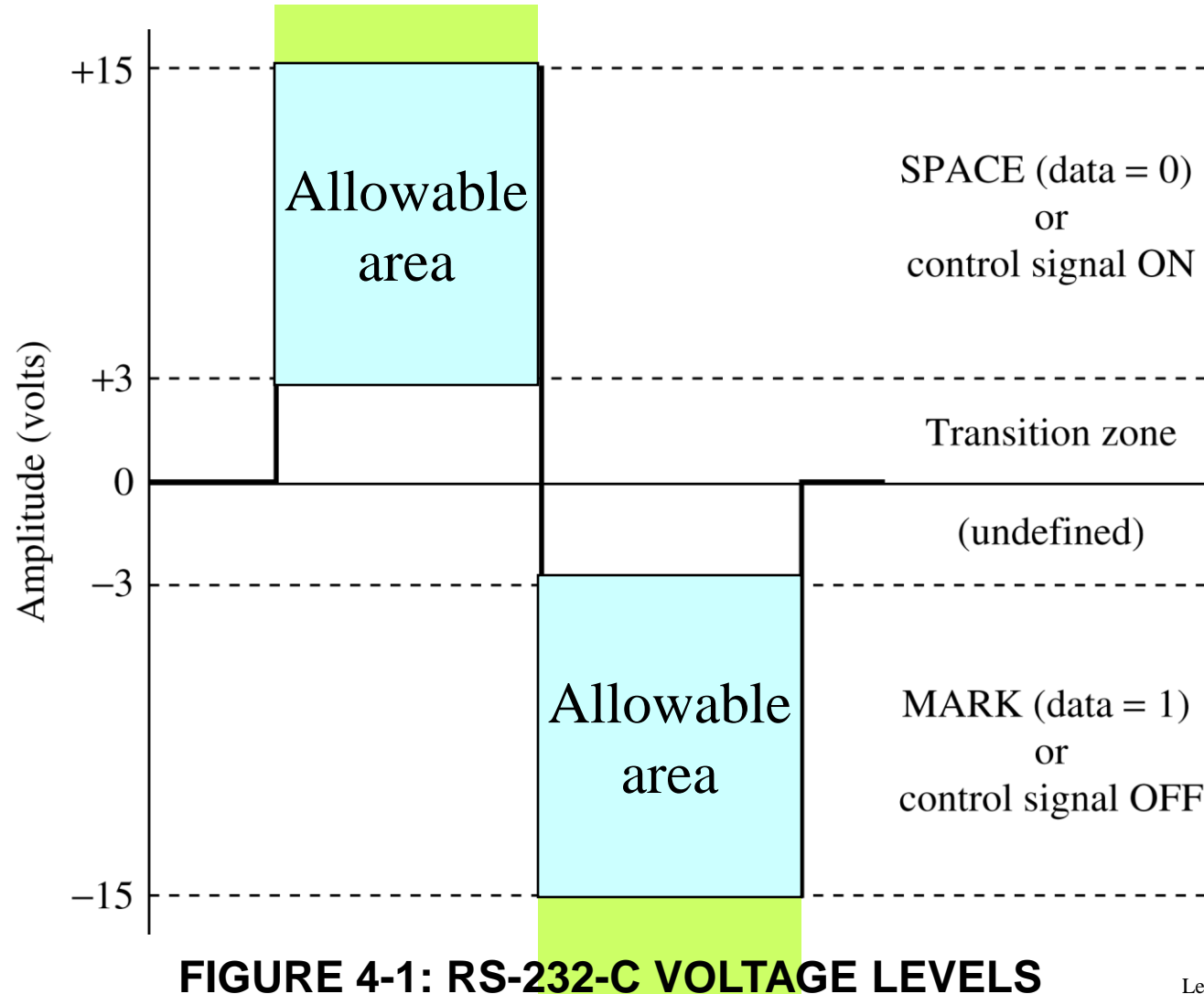


FIGURE 4-1: RS-232-C VOLTAGE LEVELS

Electrical Specification

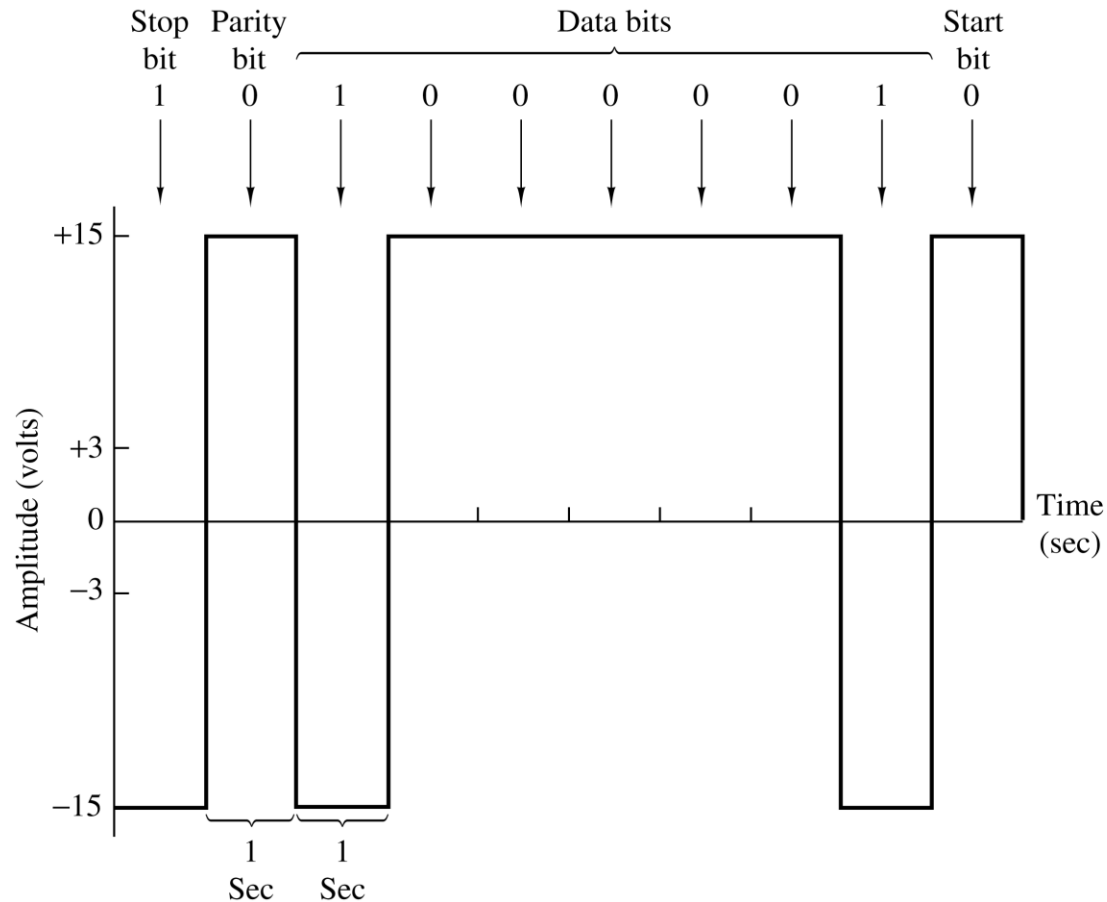
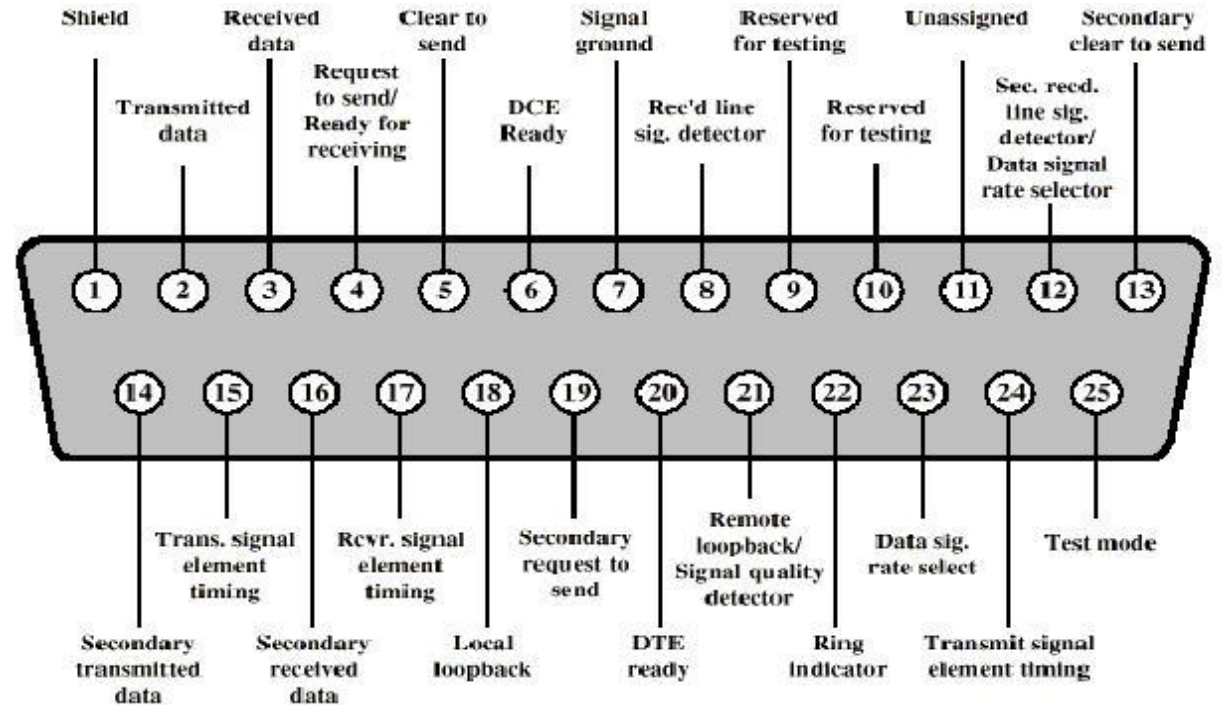


FIGURE 4-2: RS-232-C TRANSMISSION OF THE ASCII CHARACTER "A"
(read right to left)

Functional Specification













Functional Specification

| Pin | Abbreviation | Name | Direction | EIA abbreviation | CCITT abbreviation |
|-----|--------------|-------------------------------|------------|---------------------|-----------------------|
| 1 | GND | Protective Ground | Both ways | AA | 101 |
| 2 | TD | Transmitted Data | DTE to DCE | BA | 103 |
| 3 | RD | Received Data | DCE to DTE | BB | 104 |
| 4 | RTS | Request to Send | DTE to DCE | CA | 105 |
| 5 | CTS | Clear to Send | DCE to DTE | CB | 106 |
| 6 | DSR | DCE is ready | DCE to DTE | CC | 107 |
| 7 | SG | Signal Ground | Both ways | AB | 102 |
| 8 | DCD | Data Carrier Detect | DCE to DTE | CF | 109 |
| 9 | | Positive Test Voltage | DCE to DTE | | |
| 10 | | Negative Test Voltage | DCE to DTE | | |
| 11 | | Unassigned | | | |
| 12 | SDCD | Secondary Data Carrier Detect | DCE to DTE | SCF | 122 |
| 13 | SCTS | Secondary Clear to Send | DCE to DTE | SCB | 121 |
| 14 | STD | Secondary Transmitted Data | DTE to DCE | SBA | 118 |
| 15 | TC | Transmit Clock | DCE to DTE | DB | 114 |
| 16 | SRD | Secondary Received Data | DCE to DTE | SBB | 119 |
| 17 | RC | Receive Clock | DCE to DTE | DD | 115 |
| 18 | | Unassigned | | | |
| 19 | SRTS | Secondary Request to Send | DTE to DCE | SCA | 120 |
| 20 | DTR | Data Terminal Ready | DTE to DCE | CD | 108.2 |
| 21 | SQ | Signal Quality Detect | DCE to DTE | CG | 110 |
| 22 | RI | Ring Indicator | DCE to DTE | CE | 125 |
| 23 | DRS | Data Rate Select | Either way | CH/CI | 111/112 |
| 24 | XTC | External Transmit Clock | DTE to DCE | DA | 113 |
| 25 | | Unassigned | | | |

FIGURE 4-5: RS-232-C SIGNALS

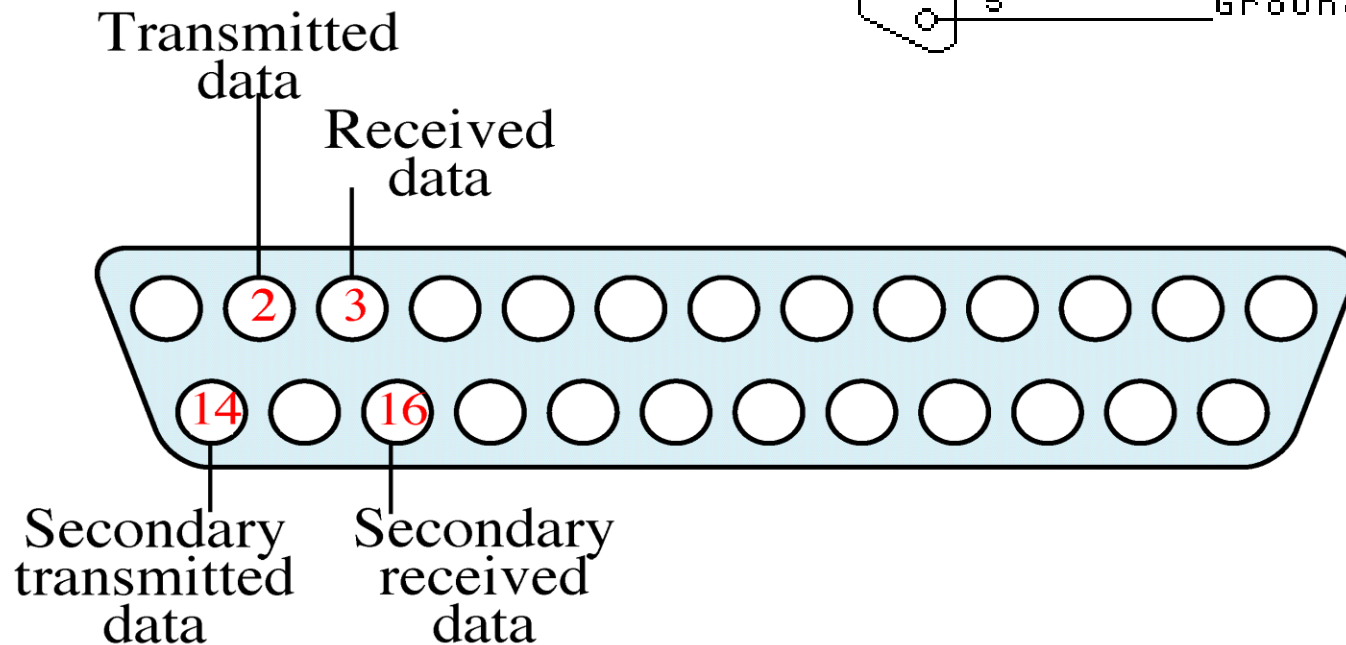
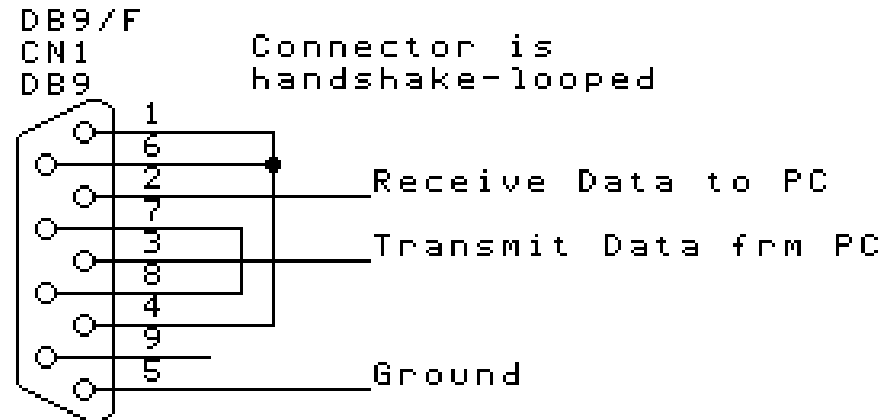
RS232 Handshake signals

| <i>Name</i> | <i>25-pin</i> | <i>9-pin</i> | <i>DTEDCE**</i> | <i>Function as seen by DTE</i> | <i>hand-shake</i> |
|-------------|---------------|--------------|---|---------------------------------|---------------------|
| <i>TD</i> | 2 | 3 |  | Transmitted data | data pair 1 |
| <i>RD</i> | 3 | 2 |  | Received data | data pair 1 |
| <i>RTS</i> | 4 | 7 |  | request to send (=DTE ready) | handshake Pair 1 |
| <i>CTS</i> | 5 | 8 |  | clear to send (=DCE ready) | handshake Pair 1 |
| <i>DTR</i> | 20 | 4 |  | data terminal ready | handshake Pair 2 |
| <i>DSR</i> | 6 | 6 |  | data set ready | handshake Pair 2 |
| <i>DCD</i> | 8 | 1 |  | data carrier detect | enable DTE input |
| <i>RI</i> | 22 | 9 |  | ring indicator | enable DTE input |
| <i>FG</i> | 1 | - |  | frame ground (chassis) | |
| <i>SG</i> | 7 | 5 |  | signal ground | |

Functional Specification (each part)

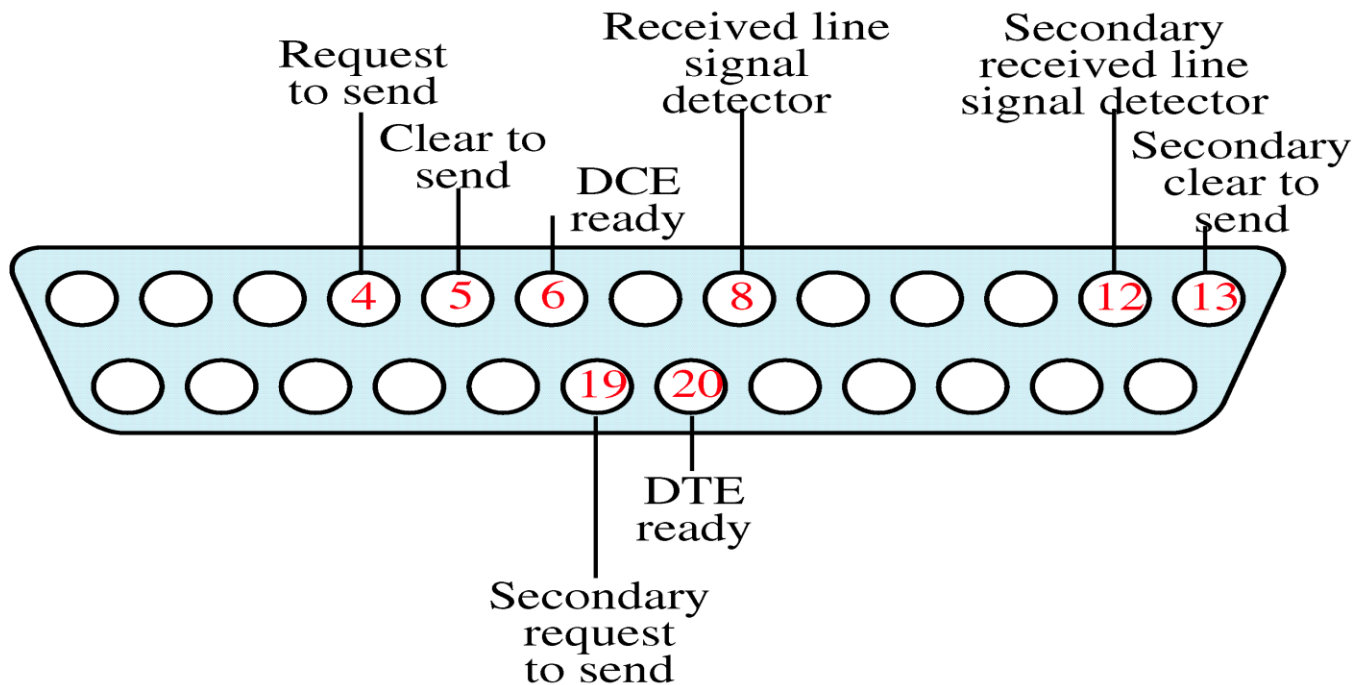
- **Data Signals**

- **2** TD : Transmitted by DTE
- **3** RD: Received by DTE
- **14** STD: Transmitted by DTE
- **16** SRD: Received by DTE



Functional Specification (each part)

- **Control Signals for asynchronous transmission**
 - 4 RTS : DTE wishes to transmit
 - 5 CTS: DCE is ready to receive;
response to Request to Send
 - 6 DSR: DCE is ready to operate
 - 20 DTR: DTE is ready to operate
 - 8 DCD: Data Carrier detector
 - 19 Secondary RTS
 - 13 Secondary CTS
 - 12 Secondary DSR



Functional Specification (each part)

- Common Control Signals:

From DTE to DCE

DTE **20** - Data Terminal Ready

RTS **4** - Request to Send

(DTE wishes to transmit)

DRS - Data Rate Select

From DCE to DTE

DSR **6** - Data Set Ready (DCE is ready to operate)

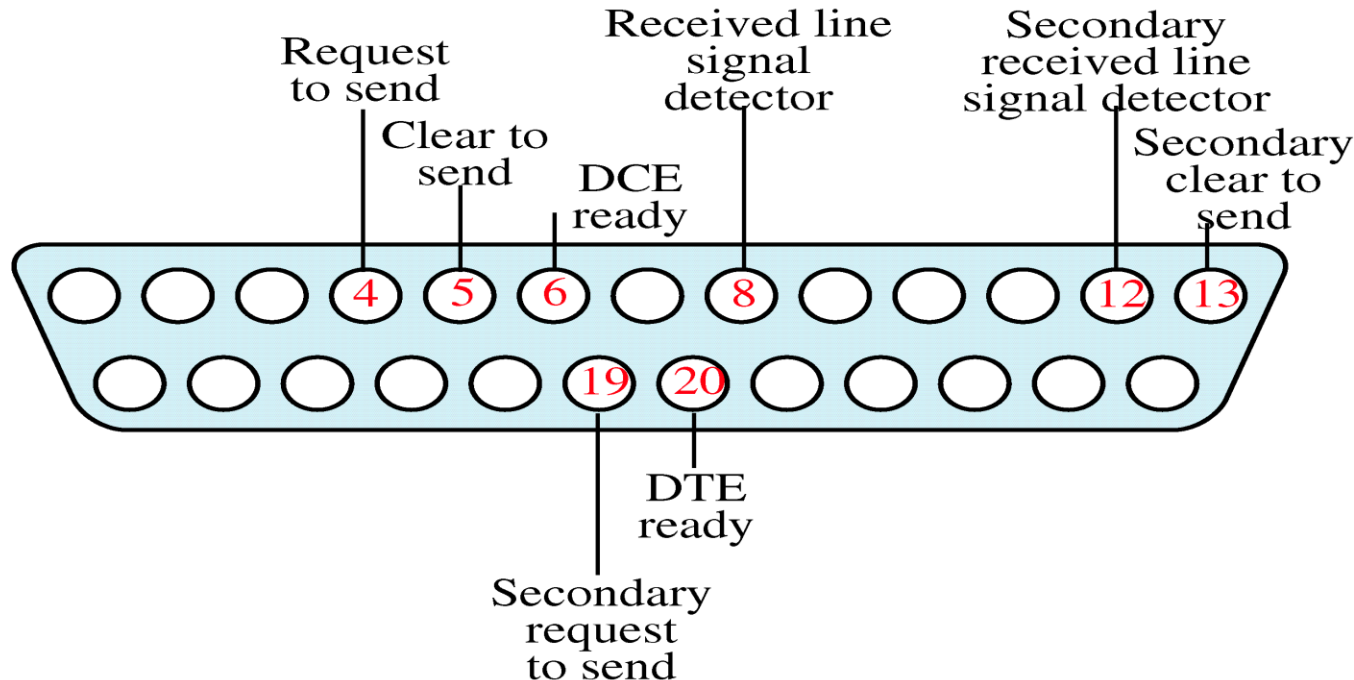
CTS **5** - Clear to Send (DCE is ready to receive)

RI - Ring Indicator

DCD - Data Carrier Detect

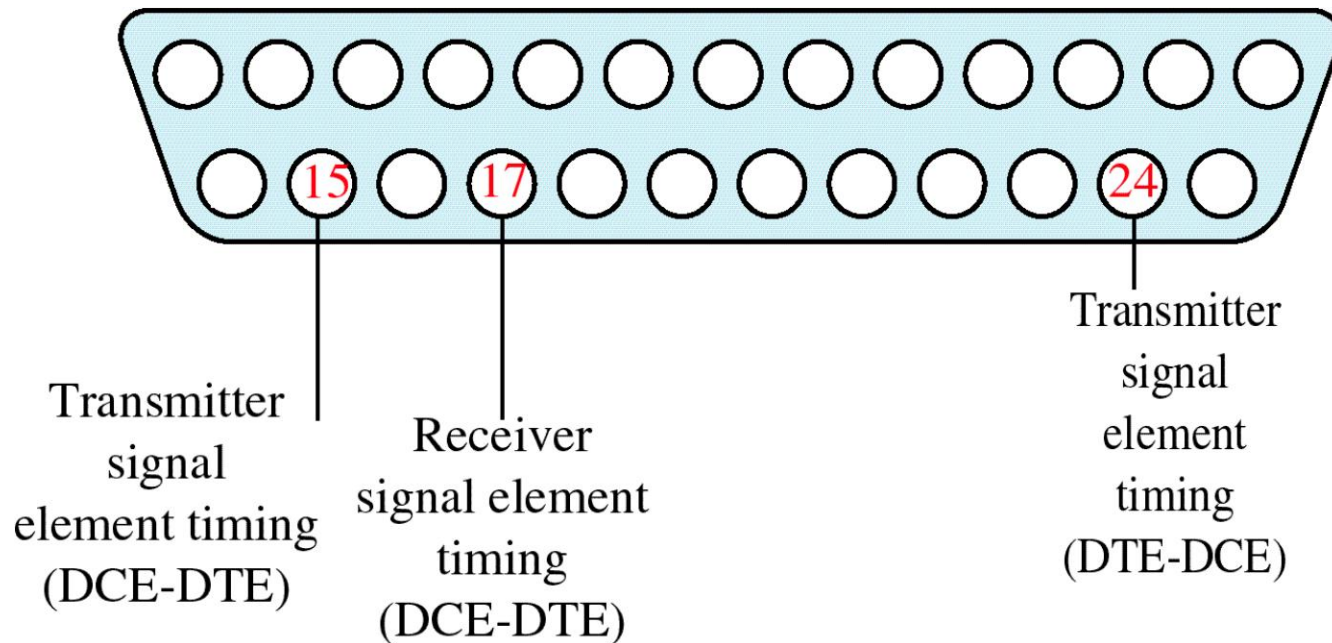
SQ - Signal Quality

DRS - Data Rate Select



Functional Specification (each part)

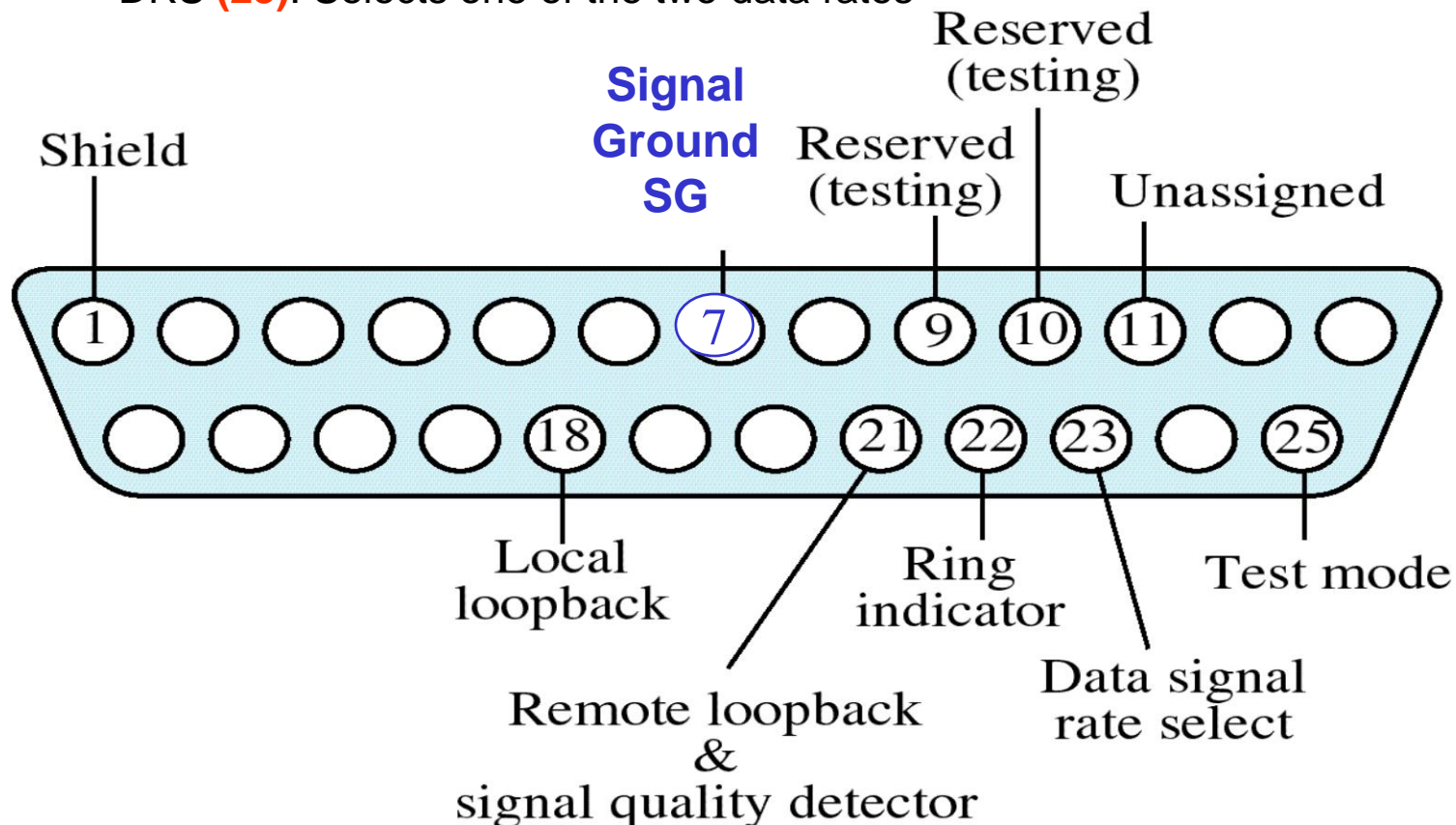
- **Timing (Transmit/receiver signal element timing)**
 - TC **(15)**: Clocking signal; both XTC and TC relate to signals on circuit TD
 - RC **(17)**: Clocking signal for circuit RD
 - XTC **(24)**: Clocking signal; transitions to ON and OFF occur at center of each signal element



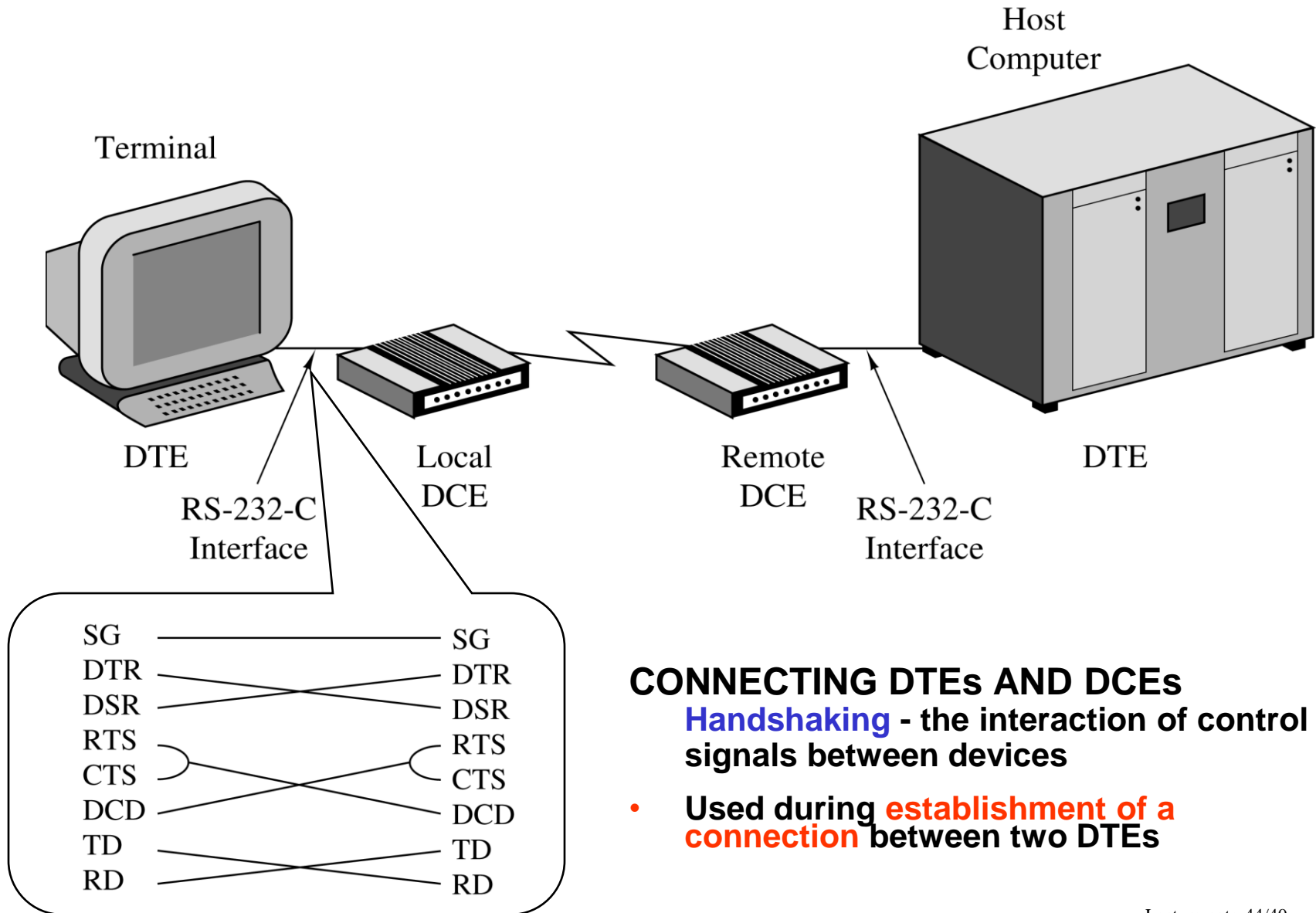
Functional Specification (each part)

- **Other parts**

- SQ (21): Indicates whether there is a high probability of error in the data received
- DRS (23): Selects one of the two data rates



Procedural Specification

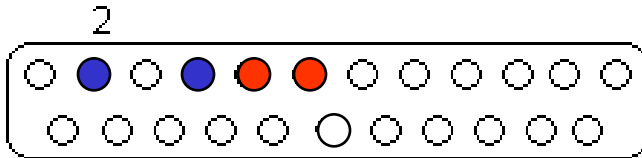


CONNECTING DTEs AND DCEs

Handshaking - the interaction of control signals between devices

- Used during **establishment of a connection** between two DTEs

Handshaking

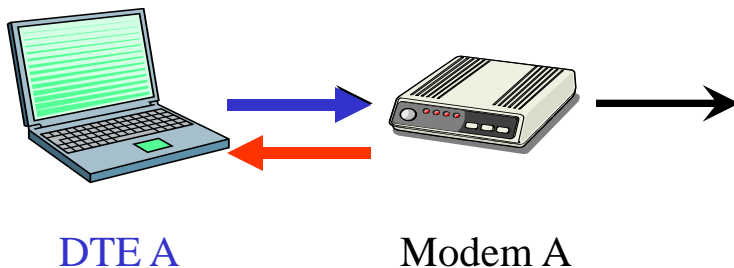


- 0-1. When DTE A is ready to send data, it asserts **Request to Send (4)**.
- 0-2. The modem A responses, when ready, with **Clear to Send(5)**, thereby indicating that data may be transmitted over circuit **TX(2)**.

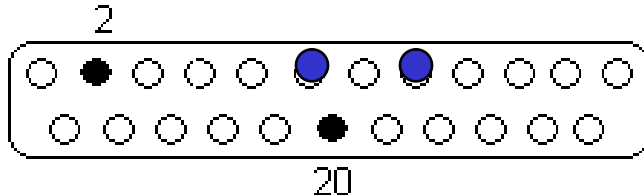
0-1. When modem A is ready to operate, the **Data Set Ready (6)** is asserted.

0-2. When DTE A is ready to send data, it asserts **Request to Send (4)**.

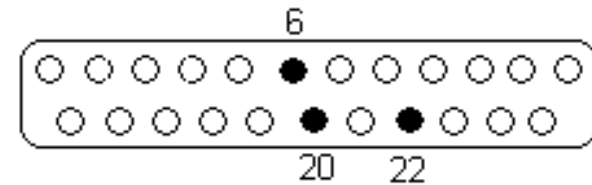
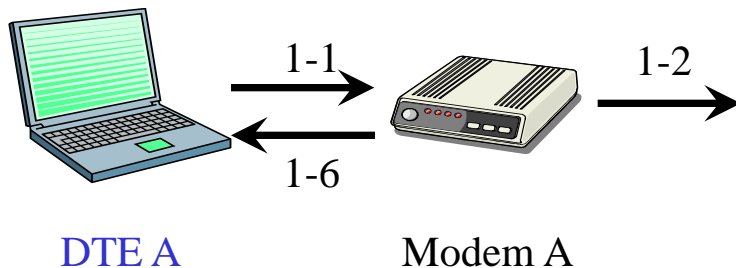
0-3. The modem A responses, when ready, with **Clear to Send(5)**, thereby indicating that data may be transmitted over circuit **TX(2)**.



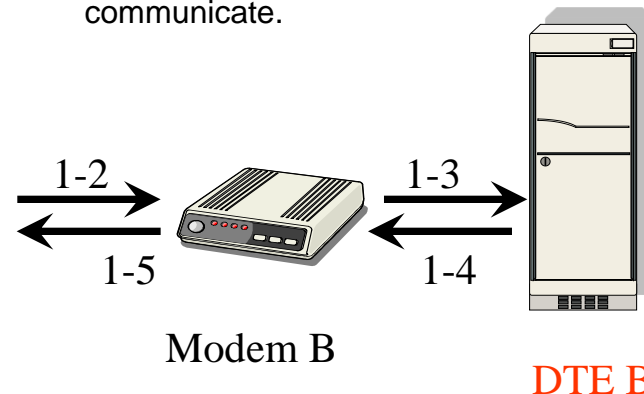
Dial Up Operation (1)-Establish connection



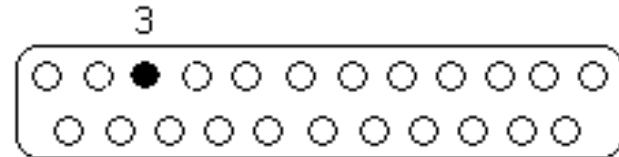
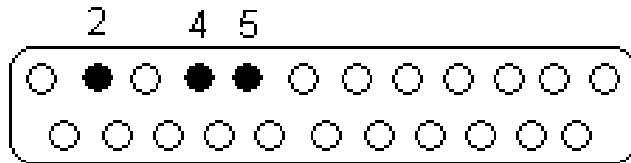
- 1-1. DTE A turns on the **DTE ready pin (20)** to tell its modem it wants to begin a data exchange while this signal remains asserted.
- 1-2. Modem A open the phone circuit and dials number. Number may be already stored in modem, or it is conveyed to the modem from DTE A via TX pin.
- 1-3. Modem B detects ring on phone line and set **Ring Indicator(22) ON**, to inform DTE B that a call has been arrived.



- 1-4. DTE B set **data Terminal Ready(20) on**, to accept the call.
- 1-5. Modem B “answers” the call by transmitting a carrier signal to modem A. it also sets **Data Set Ready(6) ON**, to indicate to TB that it is ready to communicate.
- 1-6. Modem A set both **Data Set Ready(6)** and **Carrier Detect (8) ON**, to indicate to TA that a circuit has been established and that is ready to communicate.



Dial Up Operation (2)-send data



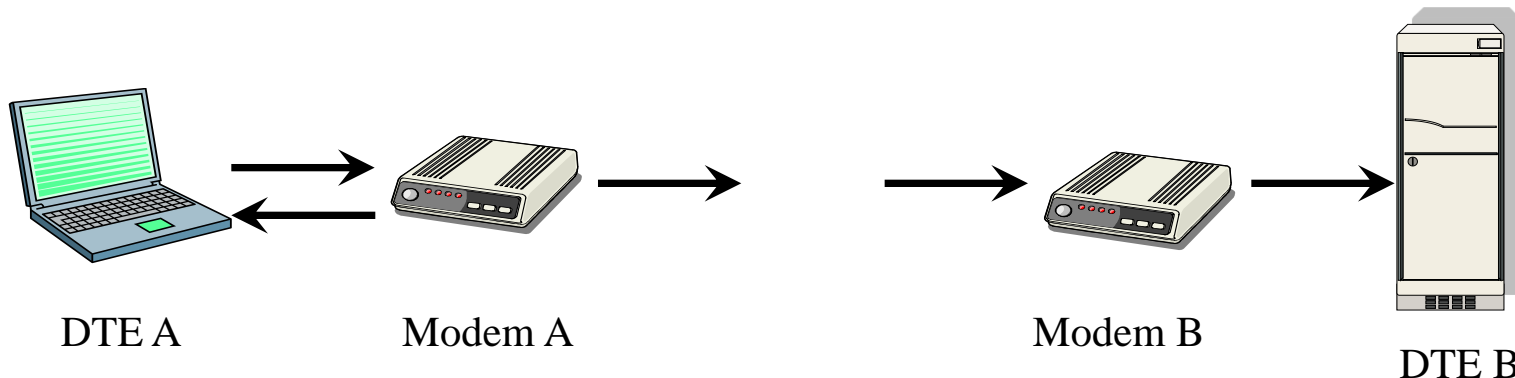
2-1 When DTE A wishes to send data, it activates **Request to Send (pin 4)**.

2-2 Modem A responds with **Clear to Send (pin 5)**

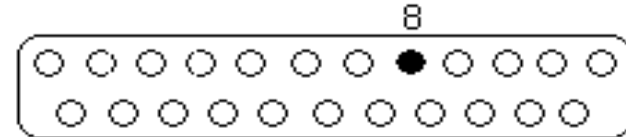
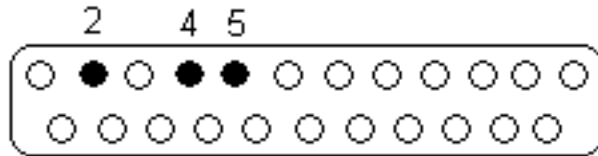
2-3 DTE A sends data (pulses representing 1s and 0s) to modem A via the transmitted Data pin (2).

2-4 Modem A modulates the pulses to send the data over its analog carrier signal (e.g. QAM)

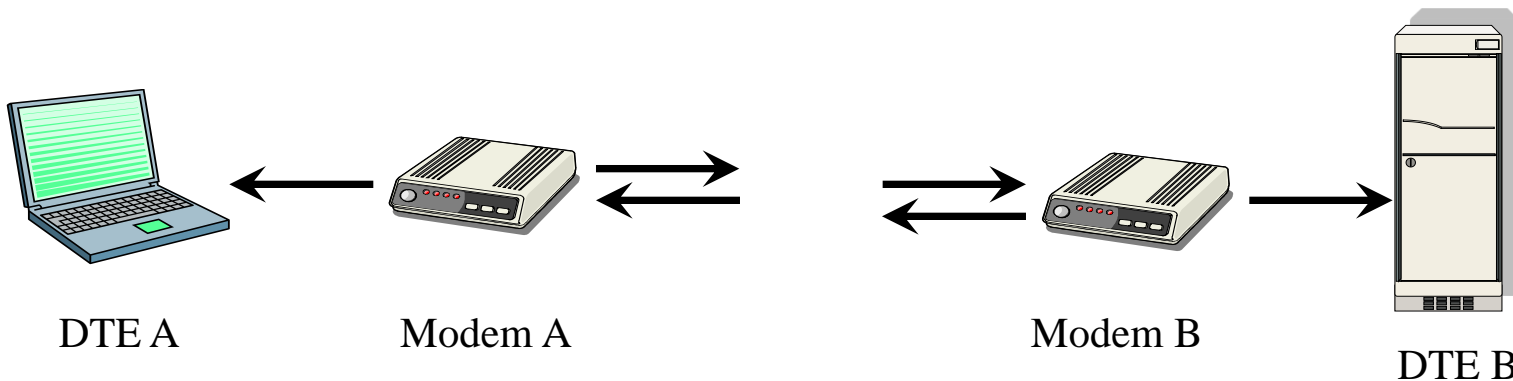
2-5. Modem B reconverts the signal to digital form and sends it to DTE B via the received Data pin (3)



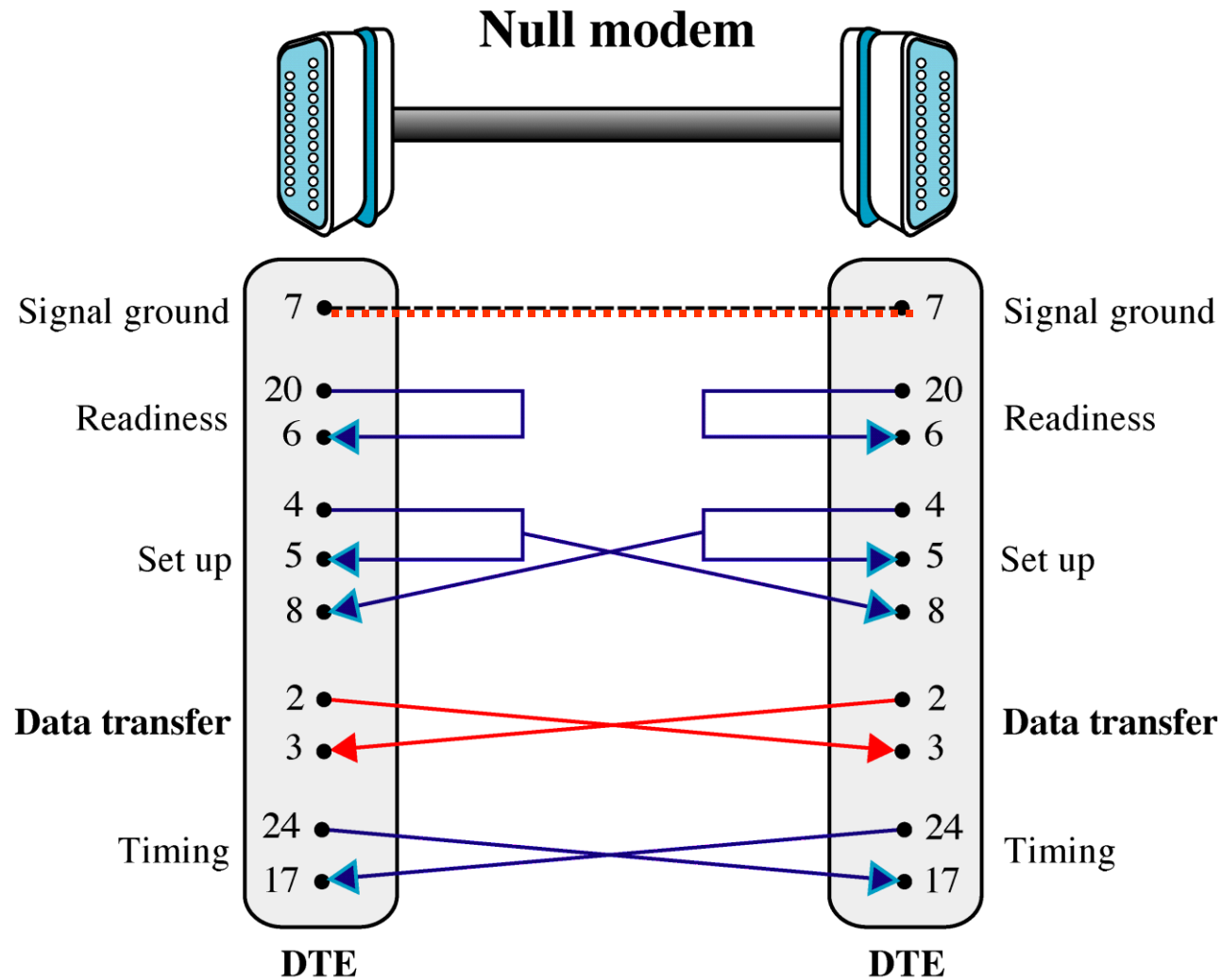
Dial Up Operation (3)-break Connection



- 3-1. When TX is finished, it sets Request to Send (pin 4) OFF.
- 3-2. Modem A detects the Request to send off, it sets Clear to Send (pin 5) OFF and drops the carrier (hangs up)



Asynchronous Transmission (DTE-DTE crossing)

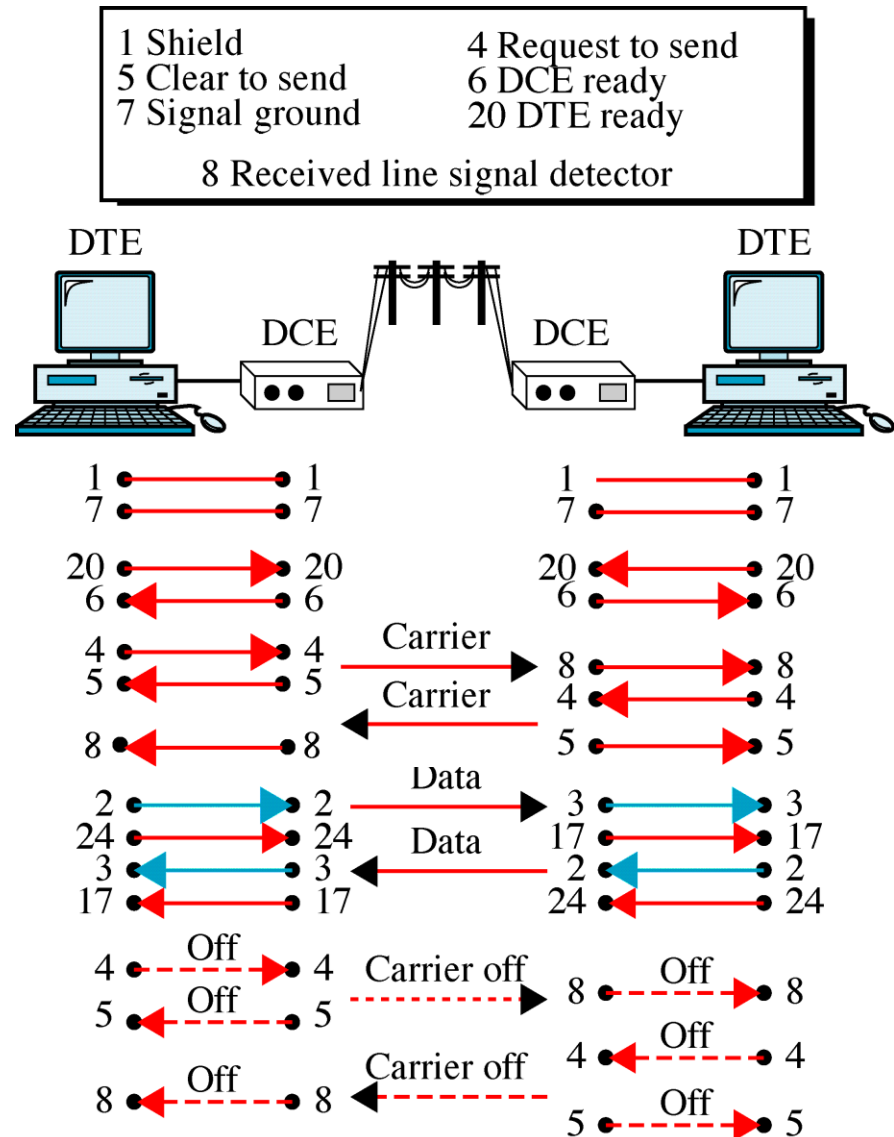


- **MINIMUM RS-232-C SIGNALS (TD, RD ,SG)**

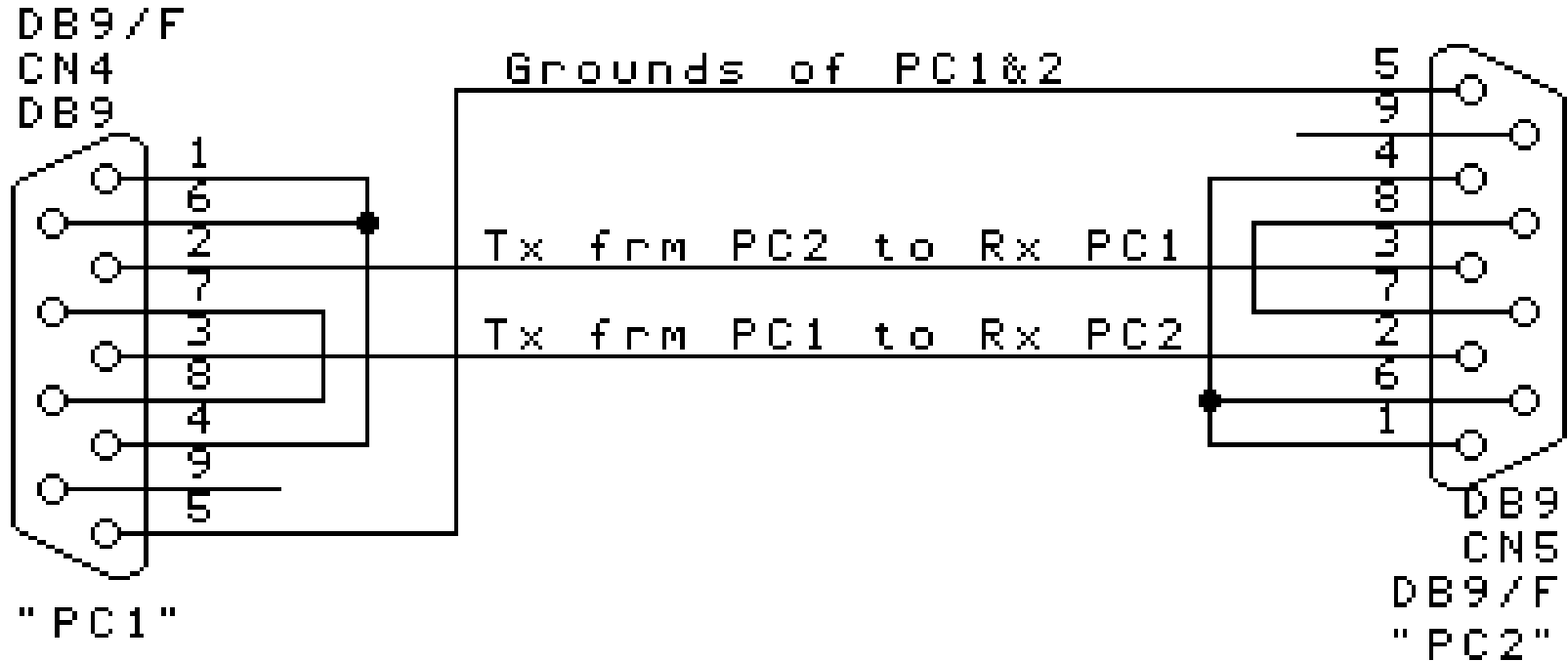
Synchronous Full-Duplex Transmission

- **Synchronous Transmission**

- TD - Transmit Data
- RD - Receive Data
- SG - Signal Ground
- TC - Transmit Clock
- RC - Receive Clock
- XTC - External Transmit Clock



Connecting together two serial devices involves connecting the Rx of one device to the Tx of the other, and vice versa. The diagram below indicates how you would go about connecting two PC's together, without handshaking.



When Handshaking is required, generally RTS of one device connects to CTS of the other, and vice versa, and also DSR of one device connects to DTR of the other device, and vice versa. The particular requirements for different equipment *may* vary.

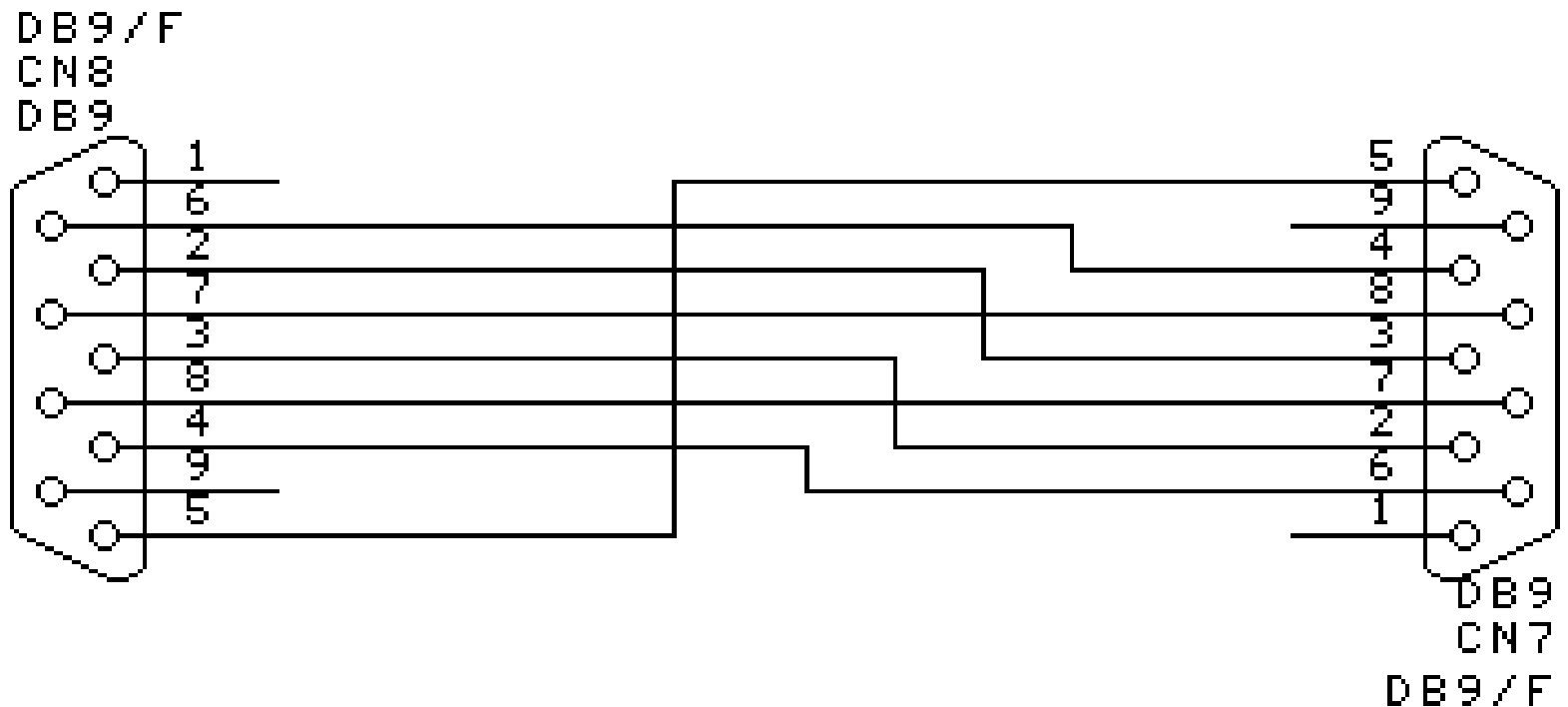
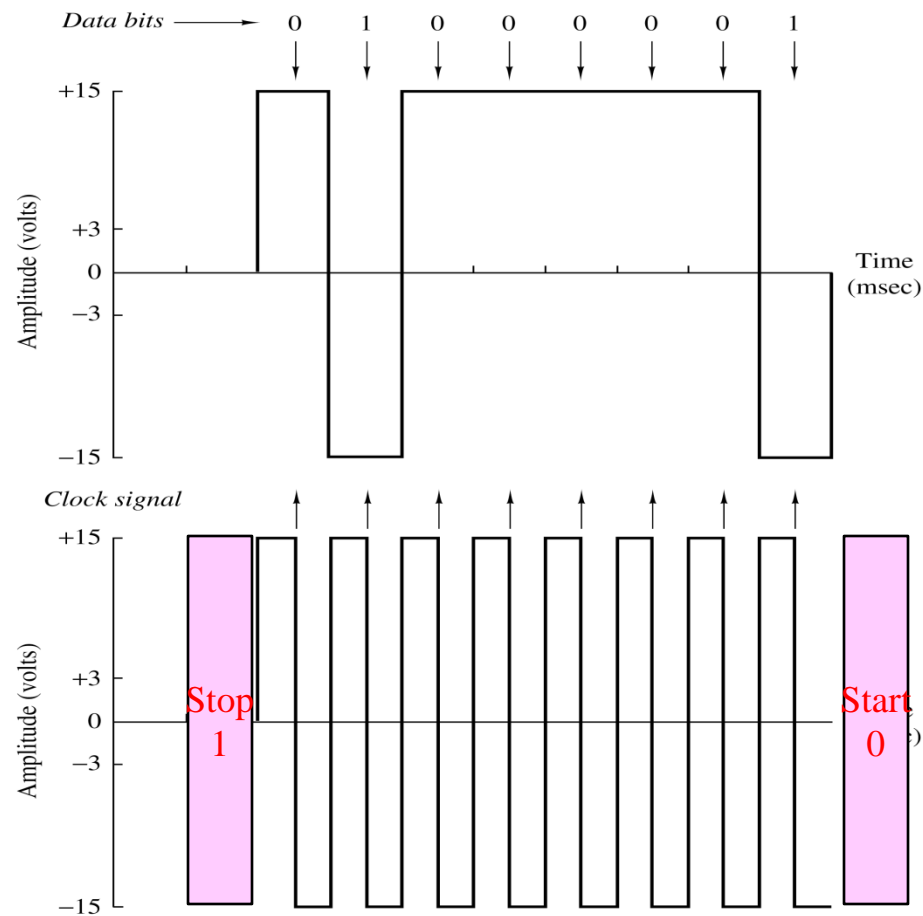


FIGURE 4-6: USING CLOCK SIGNALS TO TIME DATA TRANSMISSION



RS-232-C CONTROL SIGNALS

- **Uses voltages to send for control purposes rather than transmission of data**
 - **+3 - +15 volts: On, Raised, Asserted**
 - **-3 - -15 volts: Off, Lowered, False**
- **Common Control Signals:**

From DTE to DCE

DTE - Data Terminal Ready

RTS - Request to Send

DRS - Data Rate Select

From DCE to DTE

DSR - Data Set Ready

CTS - Clear to Send

RI - Ring Indicator

DCD - Data Carrier Detect

SQ - Signal Quality

DRS - Data Rate Select

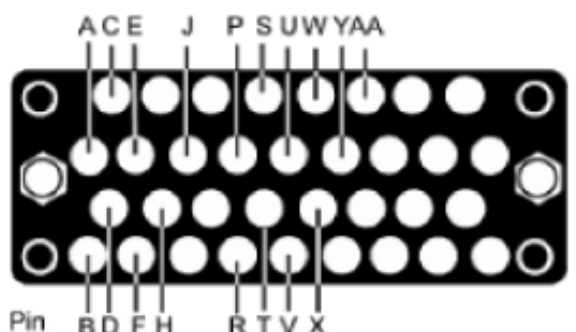
PROBLEMS WITH RS-232-C

- **Uses one wire for each signal, with no return, and a common signal ground**
- **Top transmission speed - 20 Kbps**
 - *(often used at higher rates but violates original standard).*
- **Distance – 50'feet (15m) between DTE and DCE**

V.35 Interface

- **RS-232 uses signals with reference to ground.**
- **V.35 receivers look for the difference between two wires.**
 - The receivers refers to each wire to the other not to ground.
- **The differential signals for V.35**
 - Labeled as either “A” and “B” or “+” and “-”.
 - “A” Connects to “A” and “B” connects to “B” .
 - “+” Connects to “+” and “-” connects to “-”.
 - The high speed signals such as data and clocks, are differential signals.
 - Control signals are non-differential like that used for RS232, V.24.

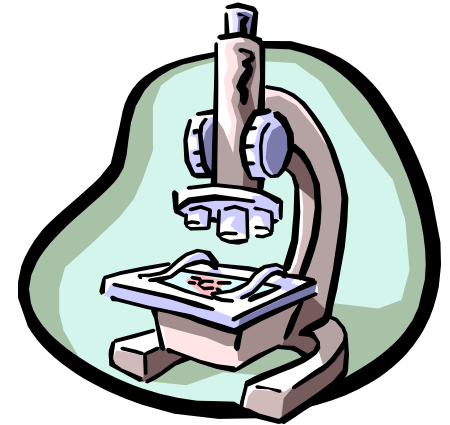
V.35 Pin Out

|  | | | |
|--|-----------------------------|-----|----------------------------|
| 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 | Received 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 |

STANDARDS ORGANIZATIONS

- **ANSI - American National Standards Institute**
- **IEEE - Institute of Electrical and Electronics Engineers**
- **EIA - Electrical Industry Association**
- **NIST - National Institute of Standards and Technology**
 - **Formerly NBS, National Bureau of Standards**
- **ITU - International Telecommunications Union**
 - **CCITT - Consultative Committee on International Telephone and Telegraph**
- **ISO - International Standards Organization**
- **IETF- Internet Engineering Task Force**

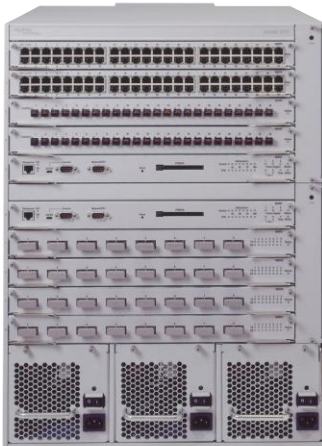
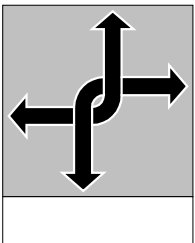
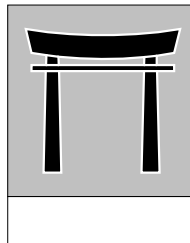
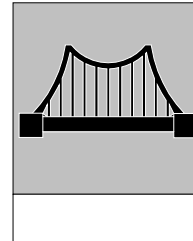
Questions



- **Research questions for Lecture 3:**
 - 1. What is transmission impairment? Describe the three types of impairment usually occur.**
 - 2. What is DSL and ADSL?**

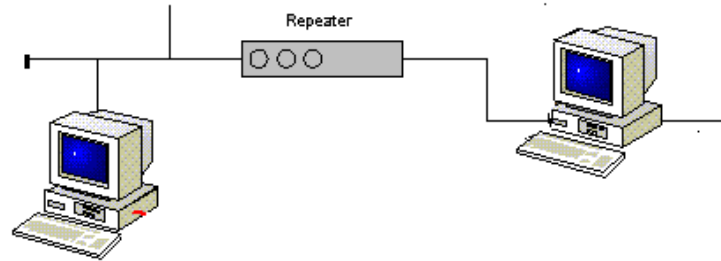
Other Network Devices

- **Repeaters – Within Segments**
- **Bridges - Within Networks**
- **Switches - Within Networks**
- **Routers - Between Networks**
- **Gateways - Between Types Of Networks**



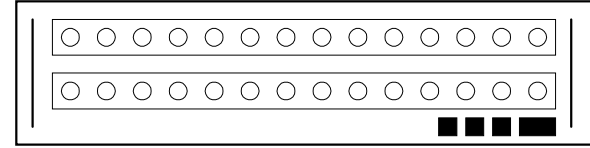
Networks that have these devices may not support Printing across them.

Hubs, Repeaters & MAUS



- **repeats a signal received on one port to all other ports**
- **regenerates, retimes and amplifies electrical signals**
- **can only connect similar network segments**

Hubs



- **10-Base-T Hubs/Concentrator**
- **Switches - Smart and Fast Hubs**
- **MAUs - IBM Token Ring**

Connect all the
network wires
together.

Repeaters

- **Operate at Layer 1**
 - Repeats traffic heard on one port to all ports
- **Can be used to interconnect differing wire types but not different access methods.**
 - i.e. up-links to fiber or coax



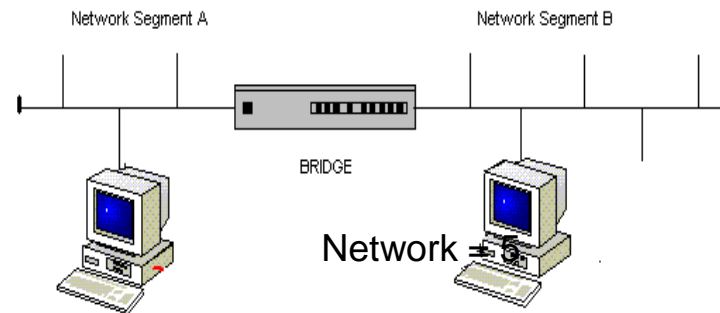
- **Daisy Chaining,**

Piggy-backing or Cascading

- Look for a special non-crossed port for interconnecting hubs to alleviate the need for cross-over cables
- Special stackable ports on some hubs allow you to stack multiple hubs as one physical repeater hop.

Bridges

- operate at Layer 2 (MAC sub-layer)
 - repeats only that traffic which is destined for the particular network
- can be used to interconnect differing access methods
 - i.e. Token Ring to Ethernet
- forward packets from one network segment to another based on MAC layer addressing

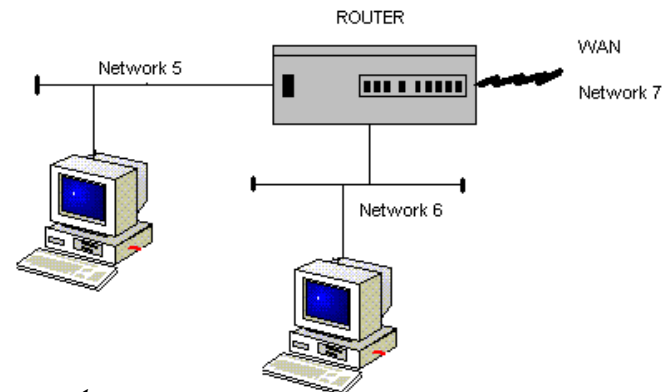


- two physical networks
- one logical
- *Broadcasts are forwarded to both sides of a bridge*

Routers

- **operate at Layer 3**
 - forwards traffic from one subnet to another based on network layer addressing
- **can be used to connect different media, different access methods and most router are also multi-protocol**
 - i.e. Coax to 10Base-T, Token Ring to Ethernet, or IP to IPX.

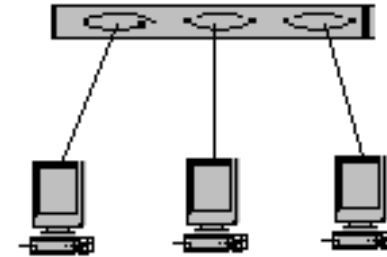
- **two physical networks**
- **two logical networks**



- *Broadcasts are not forwarded through a router*

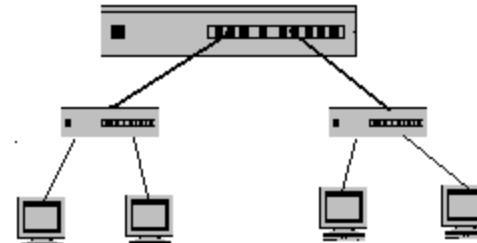
Switches

- ***“fast bridge”***
 - provides dedicated bandwidth to each switched port



Workgroup Switch - Dedicated bandwidth to each node

- may operate at Layer 2 or 3, even 4
 - 2 - bridging
 - 3 - routing at wire speed
 - 4 - QoS for application flows



Backbone Switch - Dedicated bandwidth to two network segments

- **virtual LANs (VLAN)**
 - logical sub-grouping of switched ports to help alleviate the affect of broadcasts in switched environments.