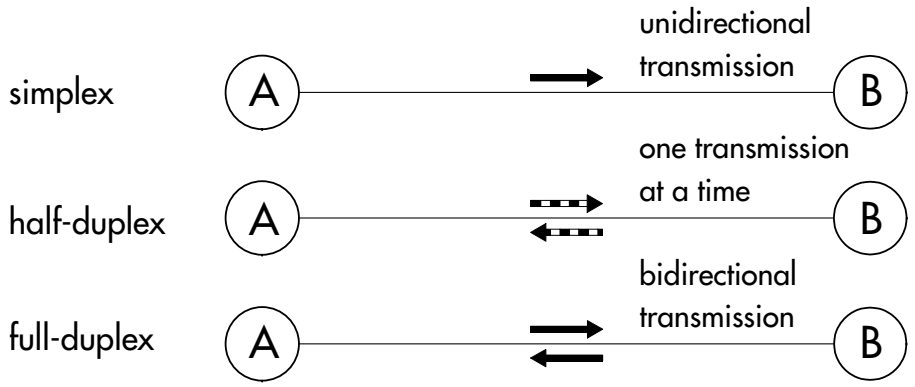
Data Communications

Prof. Dr. M. Zahurul Haq
zahurul@me.buet.ac.bd
http://teacher.buet.ac.bd/zahurul/

Department of Mechanical Engineering
Bangladesh University of Engineering & Technology

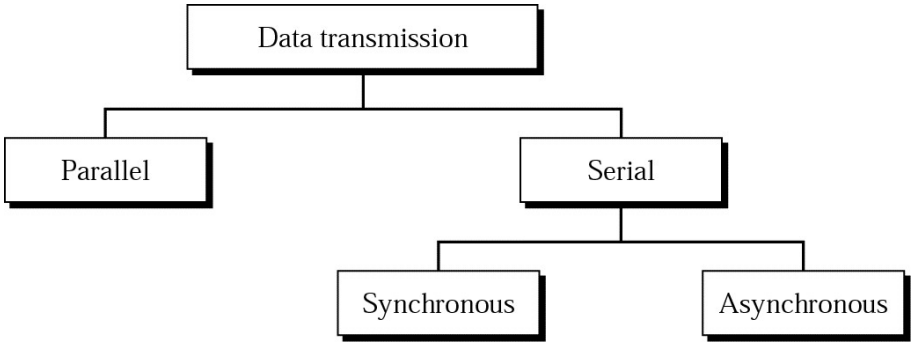
ME 475: Mechatronics

Data Transmission Modes



e068.eps

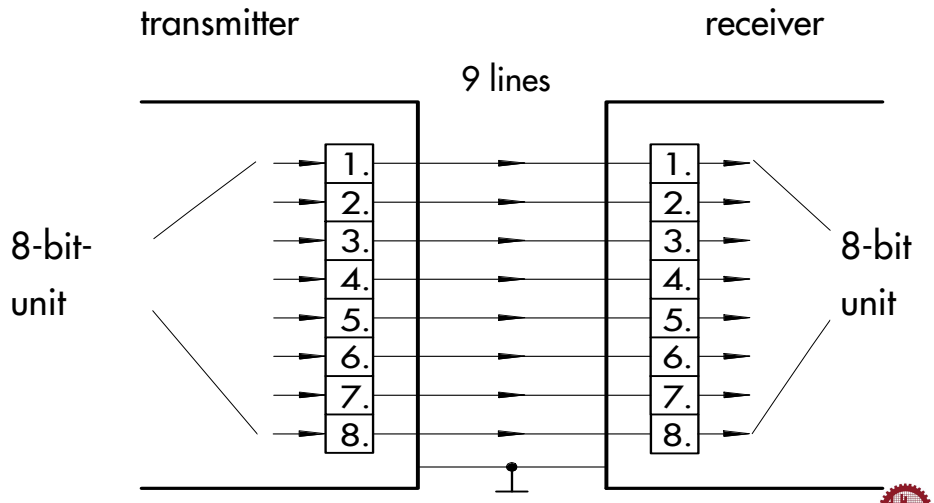
Data Transmission Types



e069.eps

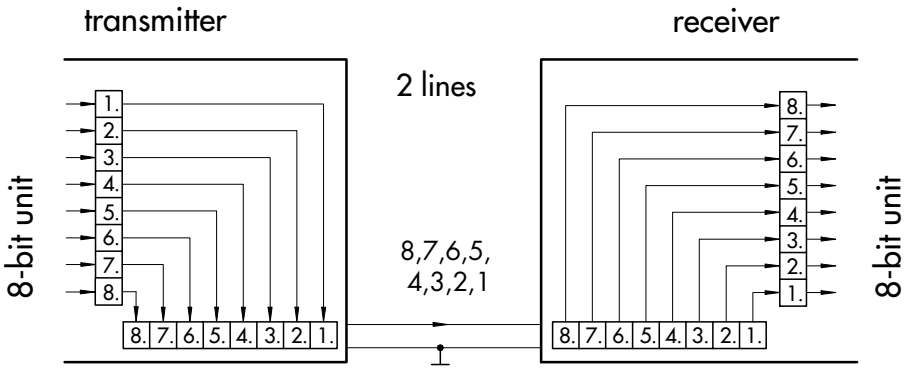
1. **Parallel** - n wires are used to send n bits at one time.
2. **Serial** - one bit follows another, so only one channel is required.

Parallel Communication



e070.eps

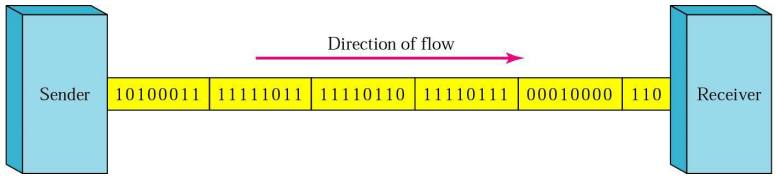
Serial Communication



e071.eps

Synchronous Serial Communication

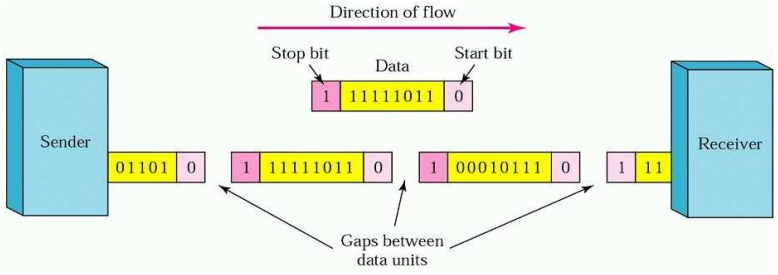
- Data are transmitted as an unbroken string of 1s and 0s, and the receiver separates that string into the bytes, or characters, it needs to reconstruct the information.
- Timing is very important, the accuracy of the received information is completely dependent on the ability of the receiving device to keep an accurate count of the bits as they come in.
- Synchronous transmissions are faster than asynchronous transmission.



e072.eps

Asynchronous Serial Communication

- Timing of a signal is unimportant, rather information is received and translated by agree-upon patterns.
- To alert the receiver to the arrival of a new group, **start bit**, usually a O, is added to the beginning of each byte.
- To inform the end of byte **stop bits**, usually 1s, are appended to the end of each byte.



e073.eps

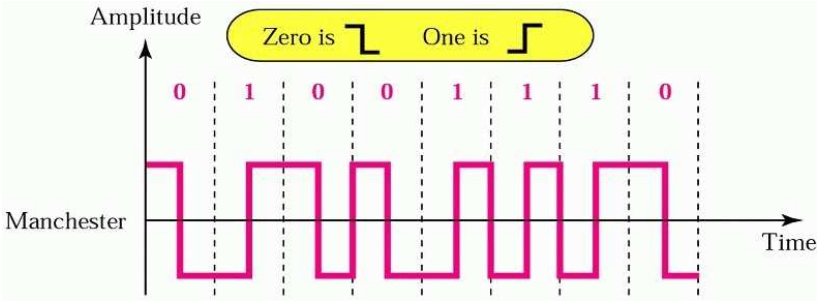
Data Conversion Methods

Transform data into signal to send from one place to another. Data conversion methods:

1. Digital-to-digital: e.g. Manchester encoding.
2. Analog-to-digital: e.g. Pulse-amplitude modulation (PAM)
3. Digital-to-analog: e.g. ASK, FSK, PSK
4. Analog-to-analog: e.g. AM, FM, PM

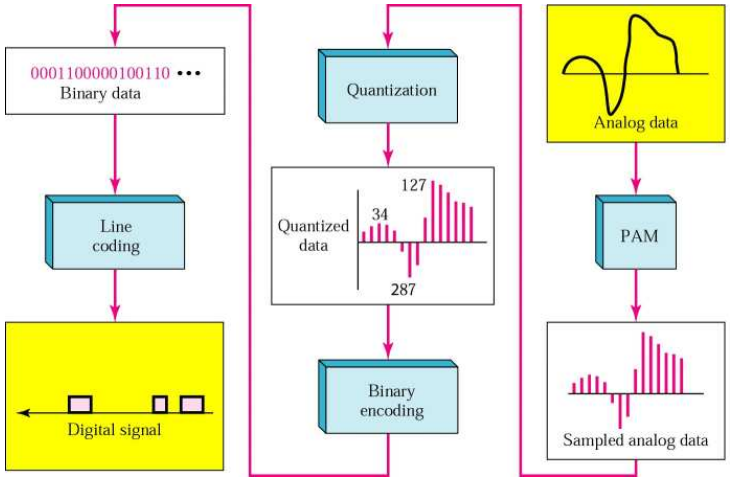
Digital-to-digital Encoding

In Manchester encoding, the bit information is included in the phase angle of the signal: a rising edge occurring in the middle of the bit time indicates 'high' state, while a trailing edge stands for 'low' state.



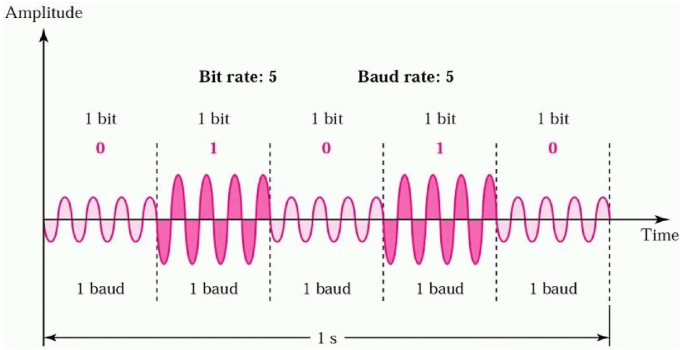
e074.eps

Analog-to-digital Encoding



e049.eps

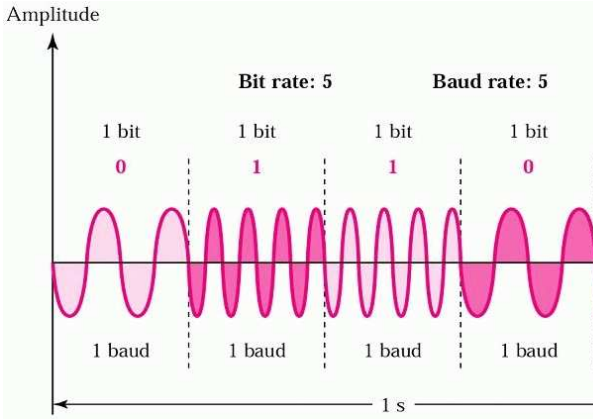
D/A Conversion: Amplitude Shift Keying (ASK)



e075.eps

Strength of the signal is varied to represent binary 1 or 0; both frequency and phase remain constant while the amplitude changes.

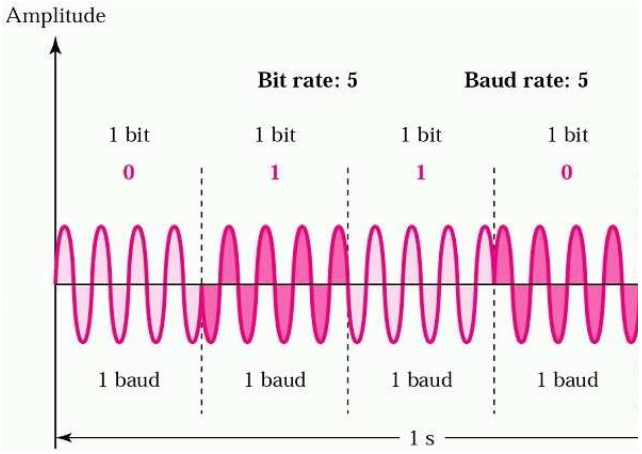
D/A Conversion: Frequency Shift Keying (FSK)



e076.eps

Frequency of the signal is varied to represent binary 1 or 0; both peak amplitude and phase remain constant.

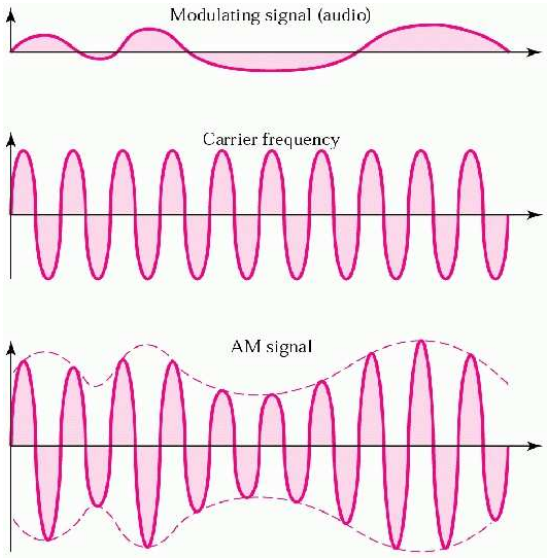
D/A Conversion: Phase Shift Keying (PSK)



e077.eps

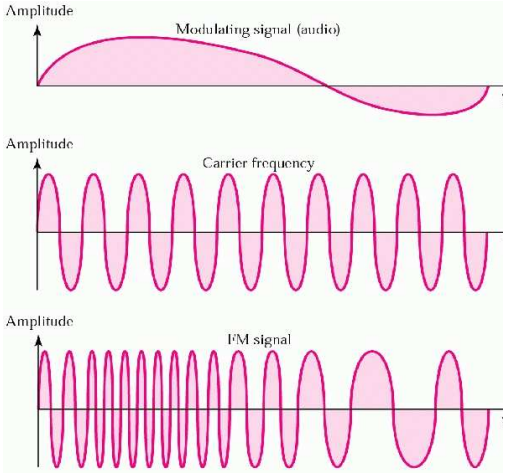
Phase of the signal is varied to represent binary 1 or 0; both frequency and peak amplitude remain constant.

A/A Conversion: Amplitude Modulation (AM)



e078.eps

A/A Conversion: Frequency Modulation (FM)

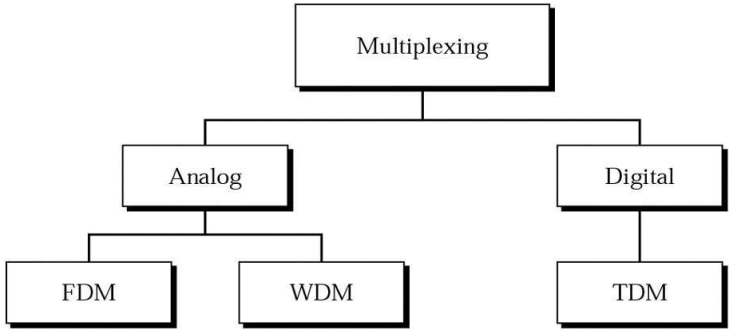


e079.eps

A/A Conversion: Phase Modulation (PM)

In PM transmission, the phase of the carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal. The peak amplitude and the frequency of the carrier signal remain constant, but as the amplitude of the information signal changes, the phase of the carrier changes correspondingly. The analysis and the final result (modulated signal) are similar to those frequency modulation.

Categories of Multiplexing



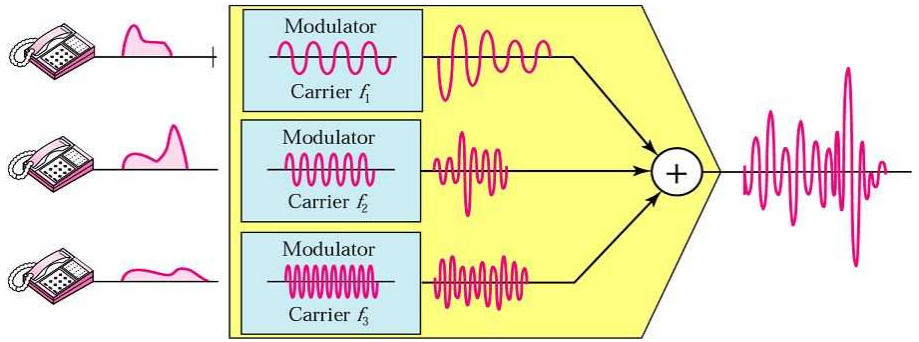
e080.eps

FDM - Frequency division multiplexing

TDM - Time division multiplexing

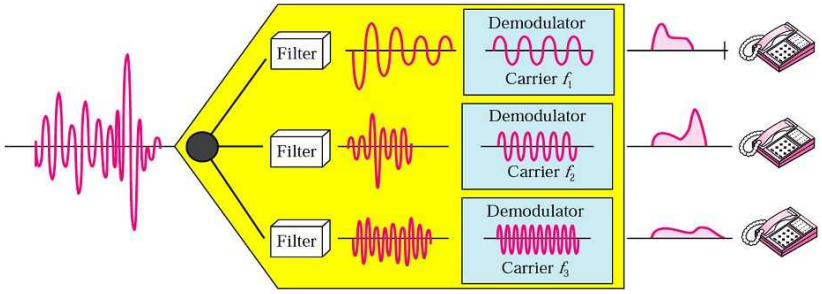
WDM - Wave division multiplexing

FDM Multiplexing, time domain



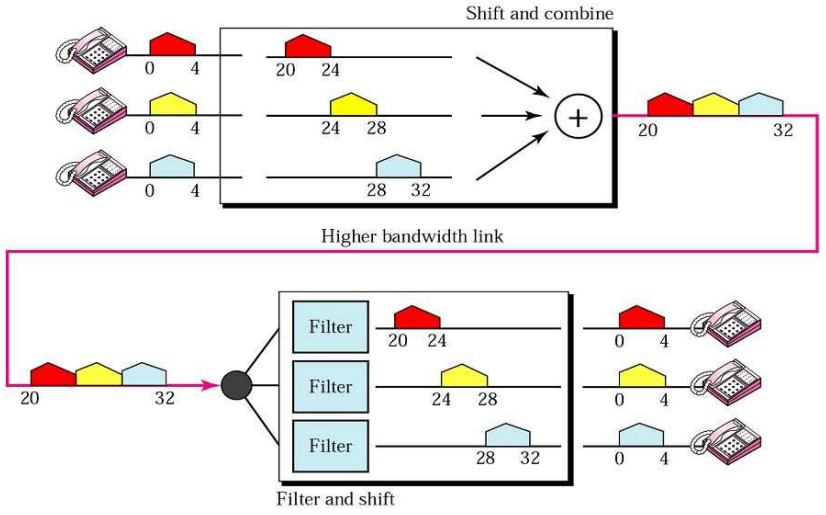
e081.eps

FDM de-Multiplexing, time domain



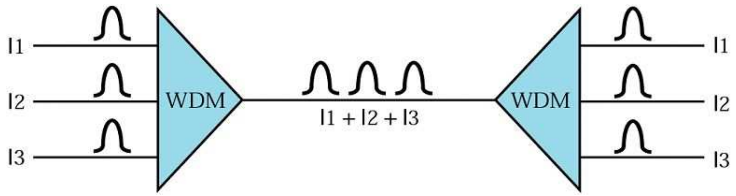
e082.eps

FDM, frequency domain

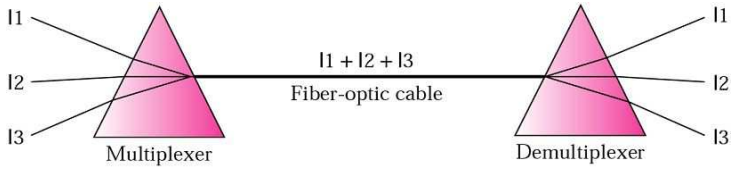


e083.eps

WDM Multiplexing and de-Multiplexing

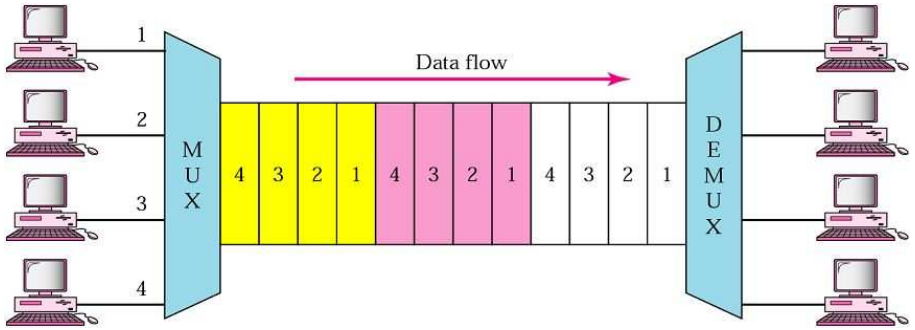


e084.eps



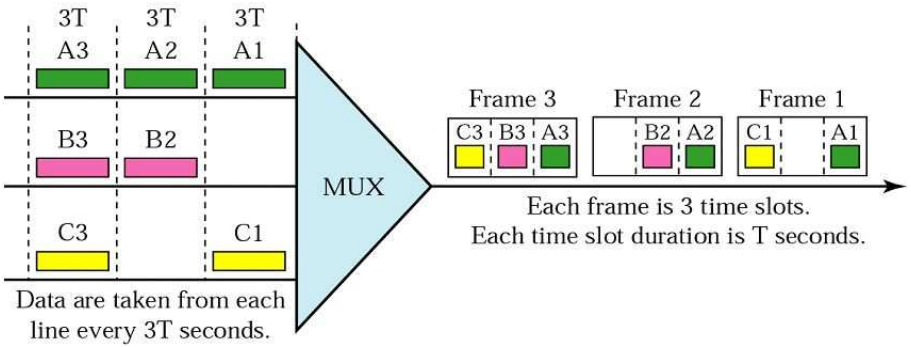
e085.eps

TDM Multiplexing



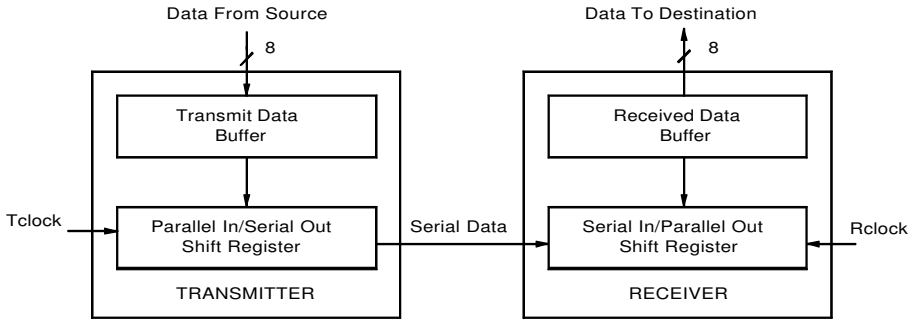
e086.eps

Synchronous TDM Multiplexing



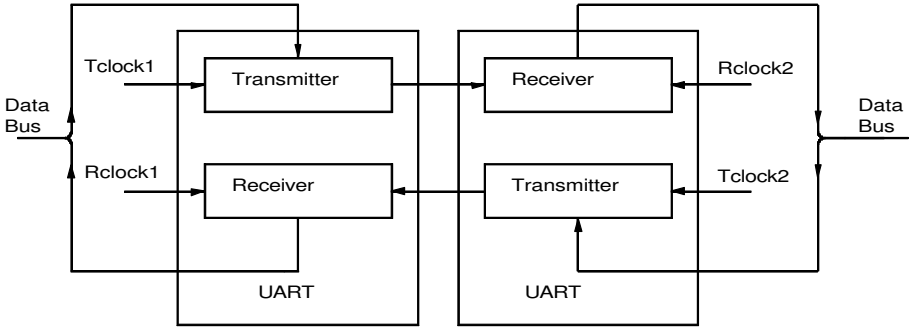
e087.eps

Components of Asynchronous Serial Comm. System



e088.eps

Universal Asynchronous Receiver/Transmitter (UART)



e089.eps

Factors in UART design

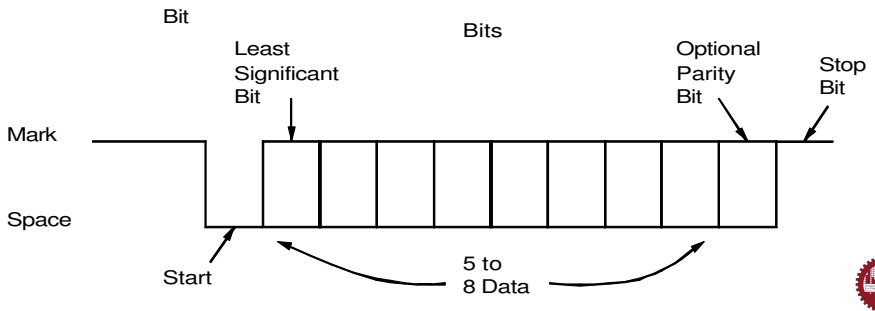
- How are the data are to be coded?
- If the data are sent in serial, which bit is sent first?
- How is the receiver synchronized with the transmitter?
- What is the data rate?
- How are the electrical signals for logic values defined?
- How does the system provide for handshaking?

Data Coding & Transmission

- Any binary code that both ends agreed upon can be used. However, the most common is the ASCII (American Standard Code for Information Exchange) code.
- The designer of UARTs have chosen to send the least significant bit first.
- Asynchronous serial communication is used as the characters can be sent as any time and not synchronized with any other processes in either sending and receiving units. To synchronize, data bits are encapsulated between two other bits known as start bit and end bit.

...

- The rate at which bits are sent is called the baud rate. The data rate can be any value, however standard baud rates are: 110, 150, 300, 600, 900, 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57800.
- The logic one and zero levels are called Mark and Space, respectively. When the transmitter is not sending anything, it holds the line at the mark level, i.e. logic one.



e090.eps

Standard Electrical Signal Levels

- 20-mA Current Loop: 20mA of current signifies a mark and zero current a space.
- TTL: a system a may define mark and space with standard TTL voltages and currents.

	TTL		CMOS	
	low	high	low	high
input	0 - 0.8 V	2.0 - 5.0 V	0 - 1.5 V	3.5 - 5.0 V
output	0 - 0.5 V	2.7 - 5.0 V	0 - 0.05 V	4.95 - 5.0 V

- TTL – Transistor-transistor logic
- CMOS – Complementary Metal Oxide Semi-conductor

Standards for Serial I/O Interfaces

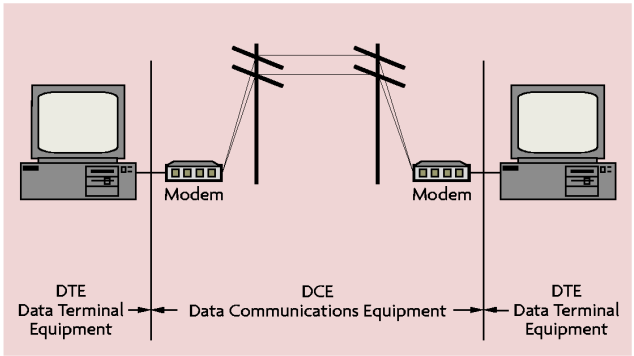
Standards are required to allow different manufacturers' equipment to be interconnected and must define the following elements:

- Handshaking signals
- Direction of signal flow
- Types of communication devices
- Connectors and interfaces
- Electrical signal levels

RS-232 is used in most serial interfaces. When the signals must transmit farther than 50 ft or greater than 20kbps, RS-422, RS-423 or RS-485 should be chosen. For each of these, handshaking, direction of signal flow and the types of communication devices are based on the RS-232C standard.

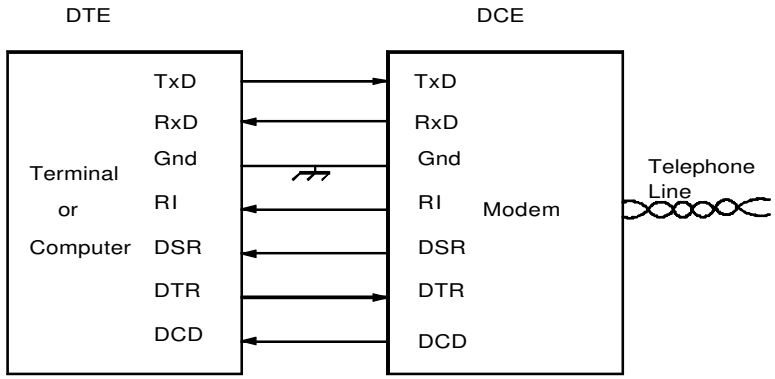
DCE-DTE Interface

- Data Circuit-Terminating Equipment (DCE) - is any device that transmits or receives data in the form of an analog or digital signal through a network.
- Data Terminal Equipment (DTE) - is any device that is a source or destination of any binary digital data.



e091.eps

Modem Handshaking Signals



e092.eps

Modem Handshaking Signals . . . contd.

- **Ring Indicator (RI)**: a special tone that rings the phone. The terminal can use RI to start some processes such as notifying the user that the other end is calling or to answer the telephone in an answer modem.
- **Data Set Ready (DSR)**: this signal tells the DTE that the modem has established a connection over the telephone line to the far end.
- **Data Terminal Ready (DTR)**: this signal comes from the DTE and informs the modem that is ready to operate.
- **Data Carrier Detect (DCD)**: sourced by DCE, received by DTE. Indicates that a DCE has detected the carrier on the telephone line.

Modem Handshaking Signals . . . contd.

- **Request to Send (RTS)**: Sourced by DTE and received by DCE. RTS is asserted by the DTE when it wants to send data. The DCE responds by asserting CTS.
- **Clear to Send (CTS)**: Received by DTE and sourced by DCE. CTS must be asserted before the DTE can transmit data.
- **Transmitted Data (TxD)**: Sourced by DTE and received by DCE. DTE cannot send unless RTS, CTS, DSR and DTR are asserted.
- **Received Data (RxD)**: Received by DTE and sourced by DCE.
- **Signal Ground (SG)**: ground reference for the signal.

Summary of Serial Communication Standards

Specification	RS-232C	RS-422	RS-423	RS-485
Driver output (V)	± 5 to ± 15	± 2 to ± 5	$\pm$ 3.6 to ± 6	± 1.5 to ± 5
Max. Data Rate	20 kb/s	10 Mb/s	100 kb/s	10 Mb/s
Max. Length	50 ft	4000 ft	4000 ft	4000 ft
No. of driver	1	1	1	32
No. of receiver	1	10	10	32