Course 10: Interfaces

Agenda

- Introduction
- V.24 interface (RS232)
- USB

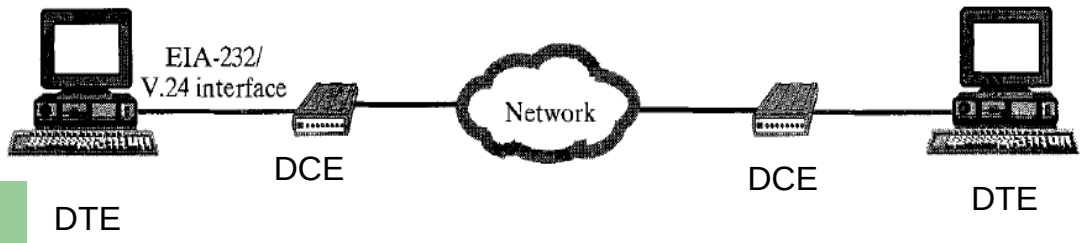
Introduction

- Definition(s) (from the web)
  - A boundary across which two independent systems meet and act on or communicate with each other. In computer technology, there are several types of interfaces. http://www.webopedia.com/TERM/I/interface.html
  - The point of interconnection between two systems or subsystems (http://en.wiktionary.org/wiki/Interface)
  - a connection between hardware devices, applications, or different sections of a computer network (www.sunrise-comp.co.uk/glossary.html)

Key terms

- DTE (Data Terminal Equipment)=end instrument that converts user information into signals for transmission or reconverts received signals into user information (e.g. PCs)
- DCE (Data Communication Equipment)=is a device that sits between the DTE and a transmission circuit (e.g.: modems)
- DCE communicates data and control info with DTE
  - Done over interchange circuits
  - Clear interface standards required

DTE and DCE…"exposed"



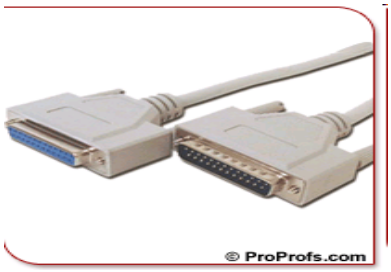
*Snapshot from W. Stallings, *Data and Computer Communications*, fifth edition, Prentice Hall International Incorporated, 1997

Interface characteristics

- Mechanical
  - Connection plugs
- Electrical
  - Voltage, timing, encoding
- Functional
  - Data, control, timing, grounding
- Procedural
  - Sequence of events

V.24 interface

- ITU-T v.24
- Only specifies functional and procedural
  - References other standards for electrical and mechanical details
- EIA-232-F (USA)
  - RS-232 (more popular name)
  - Mechanical ISO 2110
  - Electrical V.28
  - Functional V.24
  - Procedural V.24



Mechanical specification

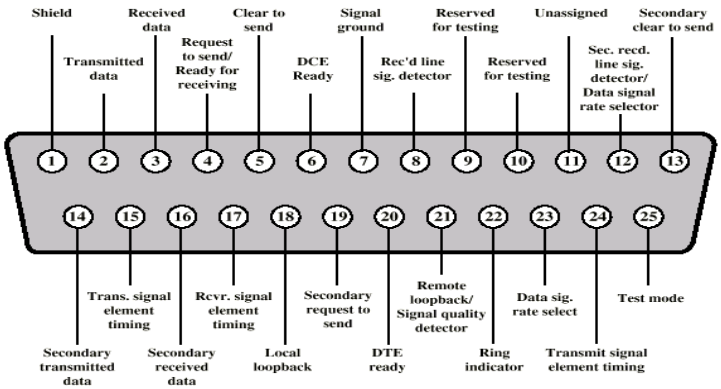


Figure 6.5 Pin Assignments for V.24/EIA-232 (DTE Connector Face)

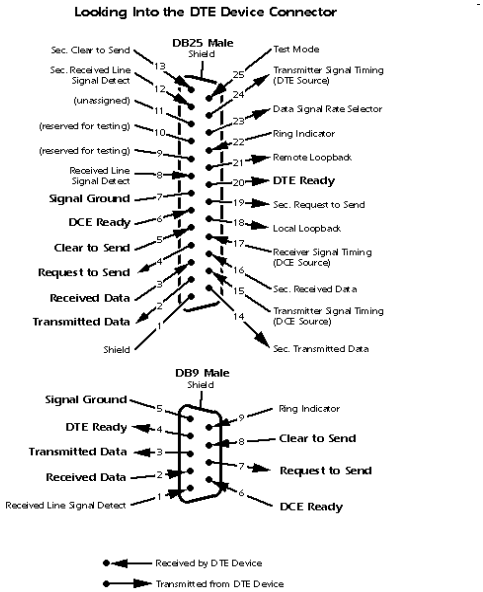
- 25 wires for serial communication
- Far fewer ports used in practice (oftentimes)

Electrical specifications

- Digital signals transmitted
- Values interpreted as data or control, depending on the circuit
- less than -3V is binary 1, more than +3V is binary 0 (NRZ-L)
  - Voltage levels below 3V are not recognized
- Signal rate < 20kbps
- Distance <15m
- For control, more than-3V is off, +3V is on

Functional specification table

Data signals				
Circuit	**Function**	**Direction to**	**Pin**	**Function**
103	Transmitted data	DCE	2	Transmitted by DTE
104	Received Data	DTE	3	Received by DTE
118	Secondary transmitted data	DCE	14	Transmitted by DTE
119	Secondary received data	DTE	16	Received by DTE
Control Signals				
105	Request to send	DCE	4	DTE wishes to transmit
106	Clear to send	DTE	5	DCE is ready to receive
107	DCE ready	DTE	6	DCE is ready to operate
108.2	DTE ready	DCE	20	DTE is ready to operate
125	Ring indicator	DTE	22	DCE is receiving a ringing signal on the channel line
109	Received line signal detector	DTE	8	DCE is receiving a signal within the appropriate limits on the channel line
110	Signal quality detector	DTE		Indicates whether there is a high probability of error in the received data
111	Data signal rate selector	DCE	23	Selects one of two data rates
112	Data signal rate selector	DTE		Selects one of two data rates
133	Ready for receiving	DCE		On/off flow control
120	Secondary request to send	DCE	19	DTE wishes to transmit on reverse channel
121	Secondary clear to send	DTE	13	DCE is ready to receive on reverse channel
122	Secondary received line signal detector	DTE	12	Same as 109, for reverse channel
140	Remote loopback	DCE		Instructs remote DCE to loop back signals
141	Local loopback	DCE		Instructs DCE to loop back signals
142	Test mode	DTE	25	Local DCE in a test condition
Timing signals				
113	Transmitter signal element timing	DCE	24	Clocking signal (transitions to ON and OFF occur to the middle of each signal element)
114	Transmitter signal element timing	DTE	15	Clocking signal (both 113 and 114 relate to signals on circuit 103)
115	Receiver signal element timing	DTE	17	Clocking signal for circuit 104
Ground				
102	Signal/ground common return		7	Common ground reference for all circuits



Functional specification

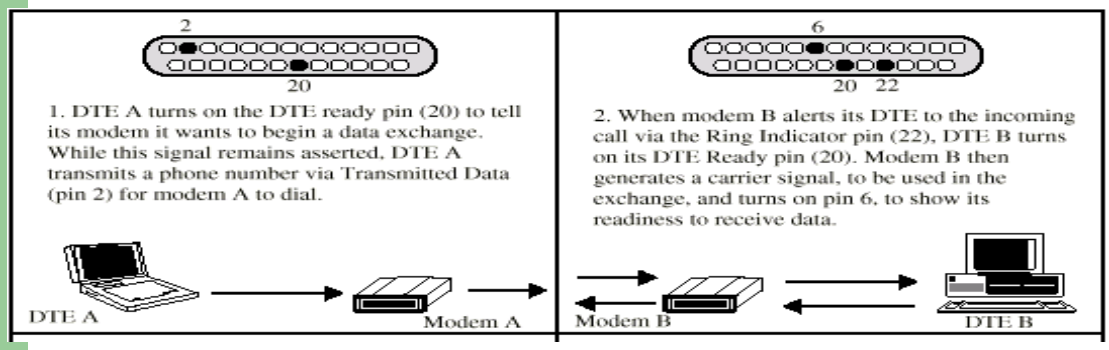
- Data, control, timing and ground circuits
- Full-duplex and half-duplex operation possible
  - Full-duplex using 103, 104
  - Half-duplex using 118, 119
- Control circuits
  - For asynchronous functioning (105, 106, 107, 108.2, 125, 109)
  - Signal quality detector (110)
  - control of the secondary channel (120, 121, 122)
  - Loopback testing (140, 141, 142)
- Timing circuits
  - Provide timing for synchronous transmission (113, 114, 115)
  - When DCE is sending synchronous data over 104, it also transmits transitions on the circuit 114 (for bit timing)
- Ground /Common return: return circuit for all data leads

Procedural specification [1]

- Example 1: Asynchronous private line modem
- When turned on and ready, the modem (DCE) applies negative voltage to DCE ready (pin 6)
- When DTE ready to send data, it asserts Request to Send (pin 4)
  - Also inhibits receive mode in half duplex
- Modem responds when ready by activating Clear to send (pin 5)
- DTE sends data
- When data arrives, local modem asserts Receive Line Signal Detector and delivers data

Procedural specification [2]

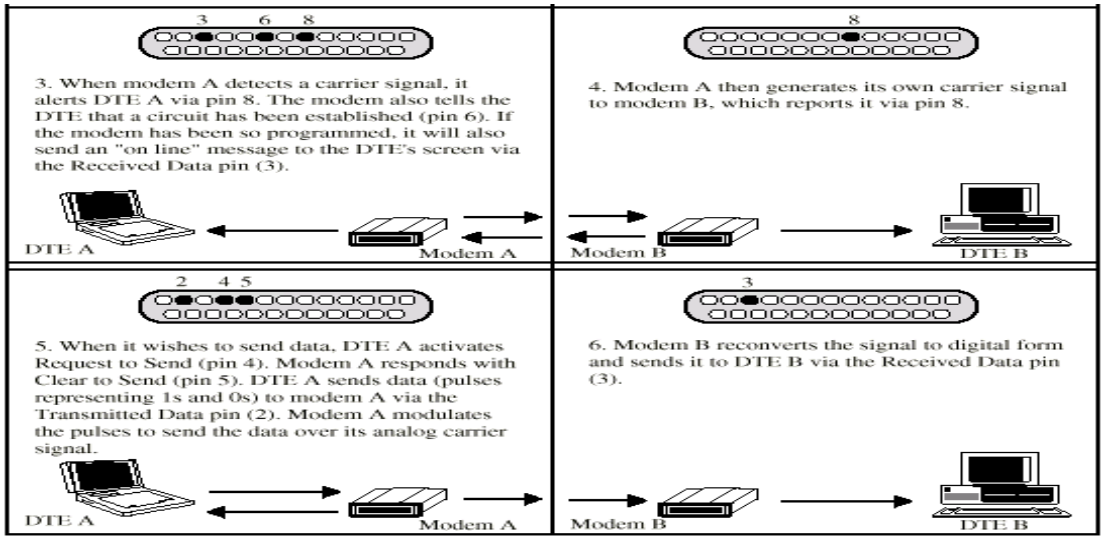
- Example 2: Telephone line-modem
- Supplementary circuits required for the operation over telephone line (DTE ready, Ring indicator)



Local modem Remote modem

Legend
3-Received data
6-DCE ready
8- Received line signal detector
2-Transmitted data
4- Request to send
5- Clear to send

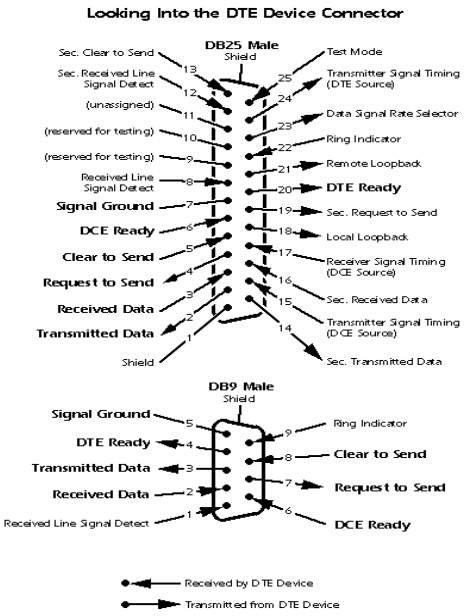
Procedural specification [3]



Local modem Remote modem

DB-9 and DB-25

- Only a small number of pins are usually employed
- DB-9, 9 pins version of DB-25 is a widely used alternative



USB Interface

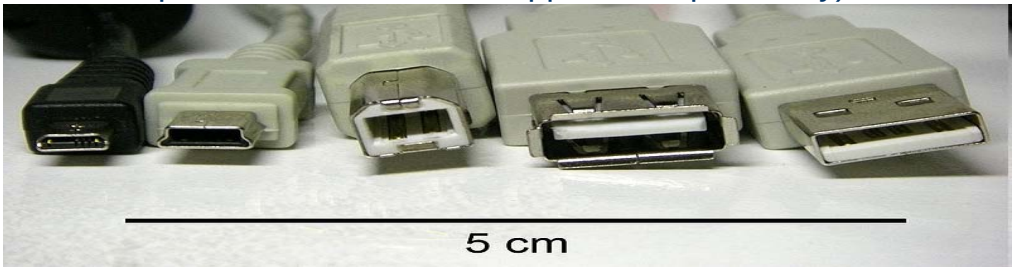
- USB = Universal Serial Bus
- Definition: serial bus standard to interface devices to a host computer
- Used for “plug-and-play” peripherals connection: mouse, keyboard, PDA, printer, scanner, digital camera
  - Power cord between devices and AC adapters
- Provides power for low-consumption devices (no need for external power supply)

History

- Version USB 1.0 created in 1996 by Intel, Compaq, Microsoft, Digital, IBM, Northern Telecom,
- first computer with USB ports produced by Apple (1998)
- USB 1.1 in 1998 and USB 2.0 in 2000
  - USB 3.0 specifications finalized in 2008, not yet a commercial product
- USB-IF= USB Implementers Forum

Features

- Serial transmission at rates for 12Mbps (USB1.0) to 480 Mbps (USB 2.0)
- Connectors: A, B, micro-A, micro-B
- USB hubs to extend the number of ports
- Supports power supply of low-consumption devices (high-consumption devices must be supplied independently)

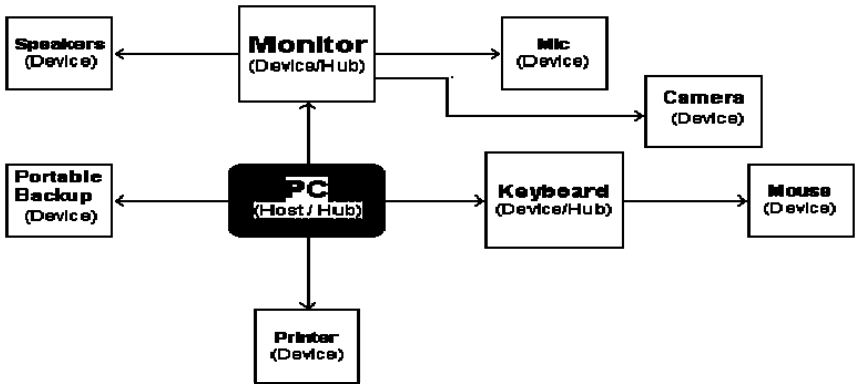


male micro USB, male mini USB B-type, male B-type, female A-type, male A-type

USB Architecture

- At least one host USB controller
- Multiple peripheral devices, connected in a star topology
- USB hubs, allowing multiple devices to connect to the same external USB port of a computer
- Functions="logical devices" (e.g: a webcam with incorporated microphone may provide video and audio functions)
- Communications based on pipes (logical channels)
- Pipes are connections from the host controller to a logical entity on the device (endpoint)
- 32 uni-directional pipes (16 upstream + 16 downstream points)

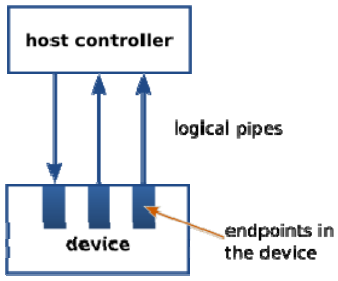
USB Topology Example



- 4 USB ports on the PC (attached devices: keyboard, monitor, memory stick, printer)
- The monitor and the keyboard have built-in incorporated hubs, allowing to connect other devices

USB Operation

- The number of end-points of a USB device: min 3, max 16
- Pipe 0 (end-point 0): used for controlling the device
- Pipe 0 used at device initialization (information obtained about other end points of the USB device)
- Endpoints characterized by: endpoint number, bus bandwidth, access frequency, latency and error handling behavior requirements.



USB Channels

- 4 types of “data channels” for the communication between the device and the USB host controller
- Control data transfer- uses pipe 0: commands towards the device or status reporting
- Isochronous transfer- for the transmission at a guaranteed speed of real time data (e.g. voice, video)
- Interruption data transfer- from some peripherals to the host (e.g. keyboard, mouse, joystick), requires small delay guarantees
- Bulk transfers: they may use the whole bandwidth, but they are not time-critical (e.g transfers to/from a storage device)
- Prioritization of the real-time traffic possible

Bus protocol

- Every device receives a 7-bits USB address upon its attachment
- Every device can transmit only if it receives an “invitation” (poll) from the host controller
- Interruption transfers are prioritized (at least 10% of each frame dedicated to this type of data)
- Isochronous devices also have dedicated bandwidth within each frame (negotiated at session setup)
- Data transmitted in frames (1000 frames/second)

Device classes

- Used to identify the USB device type

Class	Usage	Description	Examples
00h	Device	Unspecified[class 0]	(Device class is unspecified. Interface descriptors are used for determining the required drivers.)
01h	Interface	Audio	Speaker, microphone, sound card
02h	Both	Communications and CDC Control	Ethernet adapter, modem, serial port adapter
03h	Interface	Human Interface Device (HID)	Keyboard, mouse, joystick
05h	Interface	Physical Interface Device (PID)	Force feedback joystick
06h	Interface	Image	Digital camera (Most cameras function as Mass Storage for direct access to storage media).
07h	Interface	Printer	Laser printer, Inkjet printer
08h	Interface	Mass Storage	USB flash drive, memory card reader, digital audio player, external drives
09h	Device	USB hub	Full speed hub, hi-speed hub
0Ah	Interface	CDC-Data	(This class is used together with class 02h - Communications and CDC Control.)
0Bh	Interface	Smart Card	USB smart card reader
0Dh	Interface	Content Security	-
0Eh	Interface	Video	Webcam
0Fh	Interface	Personal Healthcare	-
DCh	Both	Diagnostic Device	USB compliance testing device
E0h	Interface	Wireless Controller	Wi-Fi adapter, Bluetooth adapter
EFh	Both	Miscellaneous	ActiveSync device
FEh	Interface	Application Specific	IrDA Bridge
FFh	Both	Vendor Specific	(This class code indicates that the device needs vendor specific drivers.)

Transmission speeds

- Low speed (<1.5 Mbps) for human interface devices (mouse, keyboard, etc)
- Full speed (<12 Mbps): legacy from USB 1.0, bandwidth shared using the principle “first-came-first-served”
- High speed (<480 Mbps), characteristic to USB 2.0
- Not all USB 2.0 devices support high speed
- Theoretical maximum speed of a USB 2.0 device: 480 Mbps
- Most of the devices barely support half of this speed
  - Signaling overhead limits the data rates
- USB-IF gives certificates of compliancy

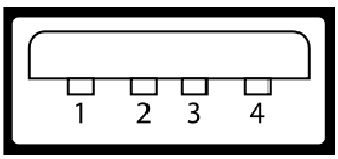
PHY layer details [1]

Pin	Name	Color	Description
1	VCC	Red	+5 V
2	D−	White	Data −
3	D+	Green	Data +
4	ID	none	permits distinction of Micro-A- and Micro-B-Plug Type A: connected to Ground Type B: not connected
5	GND	Black	Signal Ground

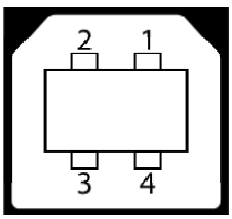
Micro USB plug

Pin	Name	Cable color	Description
1	VCC	Red	+5V
2	D−	White	Data −
3	D+	Green	Data +
4	GND	Black	Ground

USB plug



USB-A connector



USB-B connector

•Transmission made on twisted-pair cables (semi-duplex)

•Voltage levels: High = (2,8-3,6) V
Low = (0-0,3)V

PHY layer details [2]

- Signal encoding: NRZI with bit-stuffing
- Only “0” introduces a change in the transmitted signal
- After six bits of “1”, a “0” is inserted (bit “stuffing”) and it is ignored by the receiver
- Synchronization byte at the beginning of the frame (01111110)
- Power supply of 5V (between 5.25 V and 4.75 V allowed)

Further evolutions: USB 3.0

- USB 3.0
  - Passed to USB-IF in November 2008, not yet commercial
  - Full-duplex support, idle and sleep mode
  - Data transfer of up to Gbps
  - Uses 8B10B encoding, linear feedback shift register (LFSR) scrambling for data, spread spectrum
- Certified Wireless USB
  - WiMedia Alliance and Ultra-WideBand common radio platform
  - Data rates of up to 480 Mbps (d<3m) and up to 110Mbps (d<10m)
  - Device & Host wire adapter needed

USB versus V.24

- Both are standardized interfaces
- Higher transmission speeds for USB (60 Mbps vs. 115Kbps)
- USB is “plug and play”, and simpler to connect
- Bus-provided power (up to 500 mA) possible for USB, only low power RS-232 devices exist
- Higher number of USB devices can be connected (compared to RS-232)
- Much easier to use RS-232 for particular, “deeper” needs (e.g.: telnet session on devices)
- USB has some issues with older operating systems

Notice

- Some of the presented pictures are downloaded from the following websites:

  www.wikipedia.org

  www.camiresearch.com

  http://www.proprofs.com