

Serial Communications

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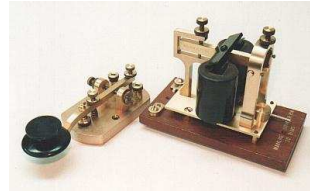
Columbia University
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Early Serial Communication

Morse code key

Letters	Numbers
A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	9
J	0
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	



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Later Serial Communication



Data Terminal Equipment



Data Communications Equipment

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RS-232

Defined in early 1960s
Serial, Asynchronous, Full-duplex,
Voltage-based, point-to-point, 100 ft+ cables

+12V } SPACE = 0
+3V }

-3V } MARK = 1
-12V }



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RS-232 Signals

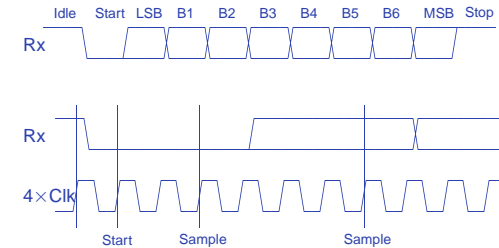


Signal DB-9 DTE ... Meaning

pin	DCE	Meaning
RxD	2	← Data received by DTE
TxD	3	→ Data sent by DTE
SG	5	— Ground
DSR	6	← Data Set Ready (I'm alive)
DTR	4	→ Data Terminal Ready (me, too)
DCD	1	← Carrier Detect (hear a carrier)
RTS	7	→ Request To Send (Yo?)
CTS	8	← Clear To Send (Yo!)
RI	9	← Ring Indicator

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Receiving RS-232



Most UARTs actually use 16x clocks

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Variants

Parity bit: (Even = true when even number of 1s)



Two stop bits:



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Baud Rate

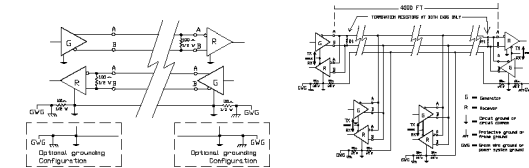
Baud: bits per second

Baud	Application
110	ASR-33 Teletype
300	Early acoustic modems
1200	Direct-coupled modems c. 1980
2400	Modems c. 1990
9600	Serial terminals
19200	
38400	Typical maximum

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Physical Variants

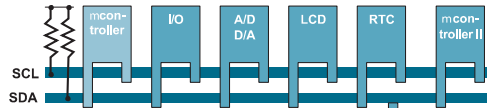
Connectors: DB-25, DB-9, Mini DIN-8
RS-422: Differential signaling RS-485: Bus-like



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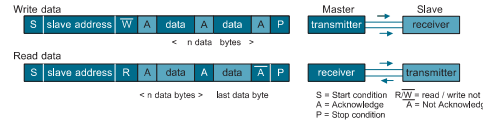
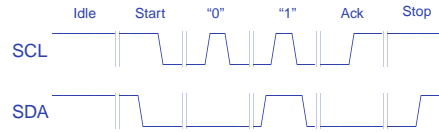
The I²C Bus

Philips invented the Inter-IC bus c. 1980 as a very cheap way to communicate slowly among chips
 E.g., good for setting control registers
 100, 400, and 3400 kHz bitrates



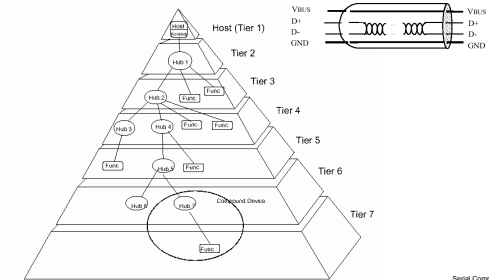
SCL: Clock, generated by a single master
 SDA: Data, controlled by either master or slaves

I²C Bus Transaction

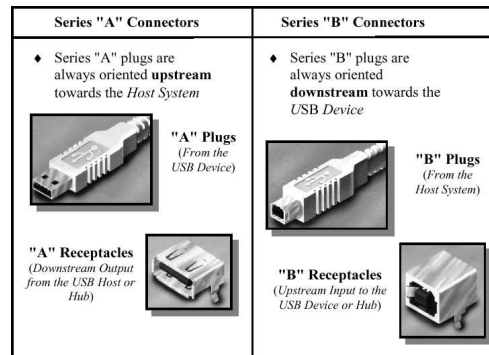


USB: Universal Serial Bus

1.5 Mbps, 12 Mbps, and 480 Mbps (USB 2.0)
 Point-to-point, differential, twisted pair
 3–5m maximum cable length



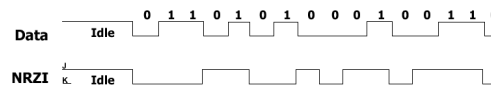
USB Connectors



USB signaling

NRZI: 0 = toggle, 1 = no change

Bit stuffing: 0 automatically inserted after six consecutive 1s



Each packet prefixed by a SYNC field: 3 0s followed by two 1s

Low- vs. full-speed devices identified by different pull-ups on D+/D- lines

USB Packets

Always start with SYNC

Then 4-bit type, 4-bit type complemented

2 bits distinguish Token, Data, Handshake, and Special, other two bits select sub-types

Then data, depending on packet type

Data checked using a CRC

Addresses (1-128) assigned by bus master, each with 16 possible endpoints

USB Bus Protocol

Polled bus: host initiates all transfers.
 Most transactions involve three packets:

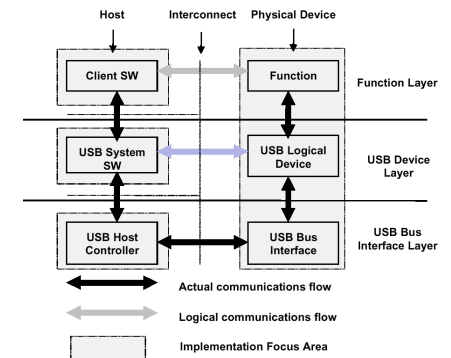
- "Token" packet from host requesting data
- Data packet from target
- Acknowledge from host

Supports both streams of bytes and structured messages (e.g., control changes).

USB Data Flow Types

- Control
 For configuration, etc.
- Bulk Data
 Arbitrary data stream: bursty
- Interrupt Data
 Timely, reliable delivery of data. Usually events.
- Isochronous Data
 For streaming real-time transfer: prenegotiated bandwidth and latency

Layered Architecture



USB: Flash Card Device

```
Bus 001 Device 002: ID 05e3:0760 Genesys Logic, Inc.
bcdUSB                2.00
bMaxPacketSize0       64
idVendor               0x05e3 Genesys Logic, Inc.
idProduct              0x0760
bcdDevice              1.14
iManufacturer         2 Genesys
iProduct               3 Flash Reader
iSerial                4 002364
Configuration Descriptor:
  bNumInterfaces       1
  MaxPower              300mA
  Interface Descriptor:
    bNumEndpoints      2
    bInterfaceClass    8 Mass Storage
    bInterfaceSubClass 6 SCSI
    bInterfaceProtocol 80 Bulk (zip)
  Endpoint Descriptor:
    bEndpointAddress   0x81 EP 1 IN
    bmAttributes        2
      Transfer Type    Bulk
      Synchron Type    none
    wMaxPacketSize     64
  Endpoint Descriptor:
    bLength             7
    bDescriptorType     5
    bEndpointAddress   0x02 EP 2 OUT
    bmAttributes        2
      Transfer Type    Bulk
      Synchron Type    none
    wMaxPacketSize     64
  Language IDs: (length=4)
    0409 English(US)
```

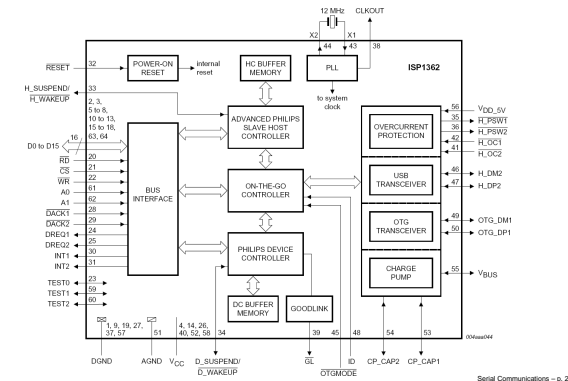
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USB: Mouse Device

```
Bus 002 Device 002: ID 04b4:0001 Cypress Semiconductor Mouse
Device Descriptor:
  bcdUSB                1.00
  idVendor               0x04b4 Cypress Semiconductor
  idProduct              0x0001 Mouse
  bcdDevice              4.90
  iManufacturer         1 Adomax Sem.
  iProduct               2 USB Mouse
  iSerial                0
  Configuration Descriptor:
    bNumInterfaces       1
    bmAttributes         0xa0
      Remote Wakeup
    MaxPower              100mA
  Interface Descriptor:
    bNumEndpoints        1
    bInterfaceClass      3 Human Interface Devices
    bInterfaceSubClass   1 Boot Interface Subclass
    bInterfaceProtocol    2 Mouse
    iInterface            5 Endpoint1 Interrupt Pipe
  HID Device Descriptor:
    bDescriptorType      34 Report
    wDescriptorLength    52
  Endpoint Descriptor:
    bEndpointAddress     0x81 EP 1 IN
    bmAttributes          3
      Interrupt
    wMaxPacketSize       4
    bInterval            10
  Language IDs: (length=4)
    0409 English(US)
```

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Philips ISP1362 USB 2.0 Controller



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Philips ISP1362 USB 2.0 Controller

- On the DE2, one downstream port, one host
- Operates at 12 or 480 Mbps speeds
- Two control endpoints + 14 user endpoints
- 4096 (host) + 2462 (device) bytes buffer memory
- Supports DMA data transfers
- Many configuration and status registers
- 150-page data "sheet" + 99-page embedded programming guide

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