Serial Communications

Early Serial Communication

RS-232

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

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>SPACE = 0</td>
</tr>
<tr>
<td>+3V</td>
<td>MARK = 1</td>
</tr>
<tr>
<td>−3V</td>
<td>MARK = 1</td>
</tr>
<tr>
<td>−12V</td>
<td>MARK = 1</td>
</tr>
</tbody>
</table>

RS-232 Signals

Signal DB-9 DTE...Meaning

<table>
<thead>
<tr>
<th>Pin</th>
<th>DCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RxD</td>
<td>Data received by DTE</td>
</tr>
<tr>
<td>TxD</td>
<td>Data sent by DTE</td>
</tr>
<tr>
<td>SG</td>
<td>Ground</td>
</tr>
<tr>
<td>DSR</td>
<td>Data Set Ready (I’m alive)</td>
</tr>
<tr>
<td>DTR</td>
<td>Data Terminal Ready (me, too)</td>
</tr>
<tr>
<td>DCD</td>
<td>Carrier Detect (hear a carrier)</td>
</tr>
<tr>
<td>RTS</td>
<td>Request To Send (Yo?)</td>
</tr>
<tr>
<td>CTS</td>
<td>Clear To Send (Yo!)</td>
</tr>
<tr>
<td>RI</td>
<td>Ring Indicator</td>
</tr>
</tbody>
</table>

Receiving RS-232

Baud Rate

Baud: bits per second

<table>
<thead>
<tr>
<th>Baud</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>ASR-33 Teletype</td>
</tr>
<tr>
<td>300</td>
<td>Early acoustic modems</td>
</tr>
<tr>
<td>1200</td>
<td>Direct-coupled modems c. 1980</td>
</tr>
<tr>
<td>2400</td>
<td>Modems c. 1990</td>
</tr>
<tr>
<td>9600</td>
<td>Serial terminals</td>
</tr>
<tr>
<td>19200</td>
<td></td>
</tr>
<tr>
<td>38400</td>
<td>Typical maximum</td>
</tr>
</tbody>
</table>

Physical Variants

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

**SCL**

**SDA**

**Idle**

**Start**

**“0”**

**“1”**

**Ack**

**Stop**

**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

<table>
<thead>
<tr>
<th>Data</th>
<th>Idle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 1 0 1 0 0 0 1 0 1 0 0 1 1 0</td>
<td></td>
</tr>
</tbody>
</table>

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**

Pollled 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 2.0

idVendor 0x05e3 Genesys Logic, Inc.
idProduct 0x0760

bcdDevice 1.14

iManufacturer 2 Genesys

iProduct 3 Flash Reader

Configuration Descriminator:

MaxPower 300mA

Interface Descriminator:

bNumEndpoints 2

bInterfaceClass 8 Mass Storage

bInterfaceSubClass 6 SCSI

bInterfaceProtocol 80 Bulk (Zip)

Endpoint Descriminator:

bEndpointAddress 0x81 EP 1 IN

bmAttributes 2

Transfer Type Bulk

Synch Type none

wMaxPacketSize 64

Endpoint Descriminator:

bLength 7

bDescriptorType 5

bEndpointAddress 0x02 EP 2 OUT

bmAttributes 2 Bulk

Synch Type none

wMaxPacketSize 64

Language Ids: [length=4]

0409 English(US)

**USB: Mouse Device**

Bus 002 Device 002: ID 04b4:0001 Cypress Semiconductor Mouse

Device Descriminator:

bNumEndpoints 1

bInterfaceClass 3 Human Interface Devices

bInterfaceSubClass 1 Boot Interface Subclass

bInterfaceProtocol 2 Mouse

Endpoint Descriminator:

bEndpointAddress 0x81 EP 1 IN

bmAttributes 3

Transfer Type Interrupt

Synch Type none

wMaxPacketSize 4

bInterval 10

Language Ids: [length=4]

0409 English(US)

**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