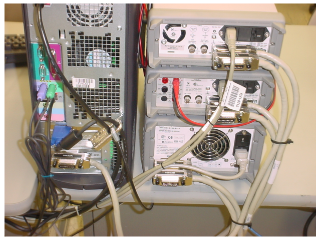
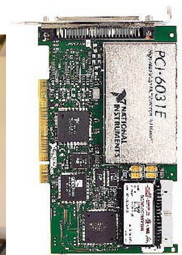




Computer Interfaces

Serial, Parallel, GPIB, CAMAC, Oh My!

Common Implementations of Interfaces

- Parallel port (8 bits per shot)
- Serial (RS-232, RS-485)
  - usually asynchronous
- GPIB (IEEE-488) parallel
  - General Purpose Interface (or Instrument) Bus
  - originally HPIB; Hewlett Packard
- DAQ card (data acquisition)
  - like national instruments A/D, D/A, digital I/O
- CAMAC
  - Computer Automated Measurement And Control
- VME bus / VXI bus
  - modern CAMAC-like bus

A quick note on hexadecimal

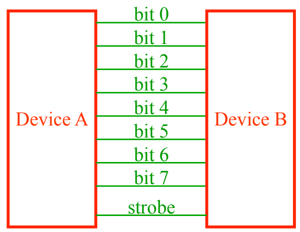
decimal value	binary value	hex value
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	a
11	1011	b
12	1100	c
13	1101	d
14	1110	e
15	1111	f

Hexadecimal, continued

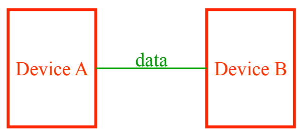
- Once it is easy for you to recognize four bits at a time, 8 bits is trivial:
  - 01100001 is 0x61
  - 10011111 is 0x9f
- Can be handy because the ASCII code is built around hex:
  - 'A' is 0x41, 'B' is 0x42, …, 'Z' is 0x5a
  - 'a' is 0x61, 'b' is 0x62, …, 'z' is 0x7a
  - '^A' (control-A) is 0x01, '^B' is 0x02, '^Z' is 0x1A
  - '0' is 0x30, '9' is 0x39

Exchanging Data

- Parallel: Fast and expensive
  - devices A, B simple, but cabling harder
  - strobe alerts to “data valid” state

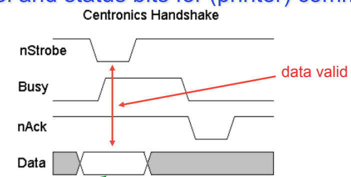


- Serial: Slow and cheap
  - but devices A and must convert between serial/parallel



The Parallel Port

- Primarily a printer port on the PC
  - goes by name LPTx: line printer
  - usually LPT1
- 8 data bits
  - with strobe to signal valid data
  - can be fast (1 Mbit/sec)
- Other control and status bits for (printer) communication



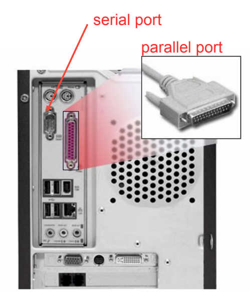
data held static for some interval

Parallel Port Pinout

Pin No (D-Type 25)	Pin No (Centronics)	SPP Signal	Direction In/out	Register	Hardware Inverted
1	1	nStrobe	In/Out	Control	Yes
2	2	Data 0	Out	Data	
3	3	Data 1	Out	Data	
4	4	Data 2	Out	Data	
5	5	Data 3	Out	Data	
6	6	Data 4	Out	Data	
7	7	Data 5	Out	Data	
8	8	Data 6	Out	Data	
9	9	Data 7	Out	Data	
10	10	nAck	In	Status	
11	11	Busy	In	Status	Yes
12	12	Paper-Out PaperEnd	In	Status	
13	13	Select	In	Status	
14	14	nAuto-Linefeed	In/Out	Control	Yes
15	32	nError / nFault	In	Status	
16	31	nInitialize	In/Out	Control	
17	36	nSelect-Printer nSelect-In	In/Out	Control	Yes
18 - 25	19-30	Ground	Gnd		

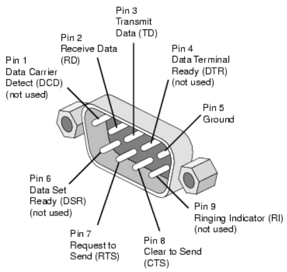
Parallel Port Access

- Most PCs have a DB-25 female connector for the parallel port
- Usually at memory address 0x378
- Windows 98 and before were easy to talk to
  - but after this, a hardware-abstraction layer (HAL) which makes access more difficult
  - one option is to fool computer into thinking you’re talking to a normal LPT (printer) device
  - involves tying pins 11 and 12 to ground
- Straightforward on Linux
  - direct access to all pins



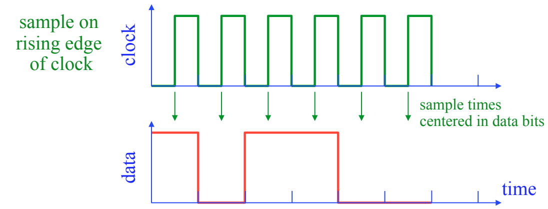
Serial Communications

- Most PCs have a DB9 male plug for RS-232 serial asynchronous communications
  - we'll get to these definitions later
  - often COM1 on a PC
- In most cases, it is sufficient to use a 2- or 3-wire connection
  - ground (pin 5) and either or both receive and transmit (pins 2 and 3)
- Other controls available, but seldom used
- Data transmitted one bit at a time, with protocols establishing how one represents data
- Slow-ish (most common is 9600 bits/sec)



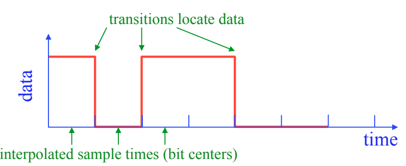
Time Is of the Essence

- With separate clock and data, the transmitter *gives* the receiver timing on one signal, and data on another
- Requires two signals (clock and data): can be expensive
- Data values are arbitrary (no restrictions)
- Used by local interfaces: V.35, (synchronous) EIA-232, HSSI, etc.
- As distance and/or speed increase, **clock/data skew** destroys timing



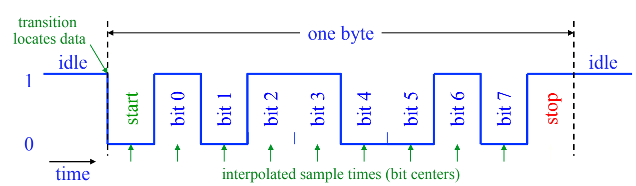
No Clock: Do You Know Where Your Data Is?

- Most long-distance, high speed, or cheap signaling is **self timed**: it has no separate clock; the receiver recovers timing from the signal itself
- Receiver knows the *nominal* data rate, but requires **transitions** in the signal to locate the bits, and interpolate to the sample points
- Two General Methods:
  - Asynchronous: data sent in short blocks called **frames**
  - Synchronous: continuous stream of bits
    - Receiver *tracks* the timing continuously, to stay in synch
    - Tracking requires sufficient **transition density** throughout the data stream
    - Used in all DSLs, DS1 (T1), DS3, SONET, all Ethernets, etc.

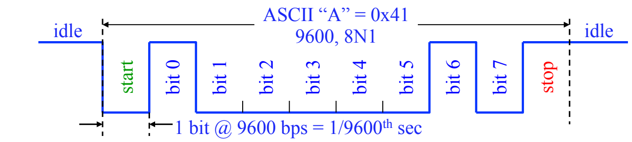


Asynchronous: Up Close and Personal

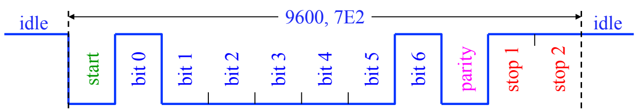
- **Asynchronous**
  - technical term meaning "whenever I feel like it"
- Start bit is always 0. Stop bit is always 1.
- The line "idles" between bytes in the "1" state.
- This guarantees a 1 to 0 transition at the start of every byte
- After the leading edge of the start bit, if you know the data rate, you can find all the bits in the byte



Can We Talk?



- If we agree on 4 asynchronous communication parameters:
  - Data rate: Speed at which bits are sent, in bits per seconds (bps)
  - Number of data bits: data bits in each byte; usually 8
    - old stuff often used 7
  - Parity: An error detecting method: None, Even, Odd, Mark, Space
  - Stop bits: number of stop bits on each byte; usually 1.
    - Rarely 2 or (more rarely) 1.5: just a minimum wait time: can be indefinite



RS-232: most common implementation

- RS-232 is an electrical (physical) specification for communication
  - idle, or "mark" state is logic 1;
    - -5 to -15 V (usually about -12 V) on transmit
    - -3 to -25 V on receive
  - "space" state is logic 0;
    - +5 to +15 V (usually ~12 V) on transmit
    - +3 to +25 V on receive
  - the dead zone is from -3 V to +3 V (indeterminate state)
- Usually used in asynchronous mode
  - so idles at -12; start jumps to +12; stop bit at -12
  - since each packet is framed by start/stop bits, you are guaranteed a transition at start
  - parity (if used) works as follows:
    - even parity guarantees an even number of ones in the train
    - odd parity guarantees an odd number of ones in the train

GPIB (IEEE-488)

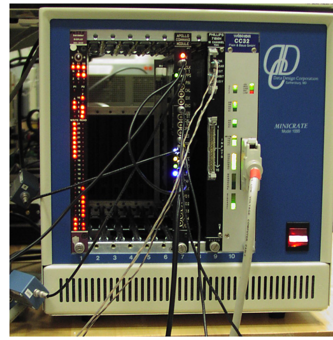
- An 8-bit parallel bus allowing up to 15 devices connected to the same computer port
  - addressing of each machine (either via menu or dip-switches) determines who's who
  - can daisy-chain connectors, each cable 2 m or less in length
- Extensive handshaking controls the bus
  - computer controls who can talk and who can listen
- Many test-and-measurement devices equipped with GPIB
  - common means of controlling an experiment: positioning detectors, measuring or setting voltages/currents, etc.
- Can be reasonably fast (1 Mbit/sec)

Data Acquisition

- A PCI-card for data acquisition is a very handy thing
- The one pictured at right (National Instruments PCI-6031E) has:
  - 64 analog inputs, 16 bit
  - 2 DACs, 16 bit analog outputs
  - 8 digital input/output
  - 100,000 samples per second
  - on-board timers, counters
- Breakout box/board recommended

CAMAC

- This somewhat old interface provides a “crate” into which one slides modules that perform specific tasks
  - A/D conversion
  - time-to-digital converters
  - pulse generators
  - charge measurement
  - amplifiers
  - delay generators
- Frequently used in timing experiments, like nuclear physics: catch events in detector, generate signal, measure strength, etc.
- Often the modules are highly multiplexed (16 channels per card common)



CAMAC crate (above) and inhabitants (right) including two custom modules, two commercial time-to-digital converters (TDCs) and the crate controller (note interface cable (50-pin SCSI-2 style)

CAMAC features

- 16-bit (newer are 24-bit) data words
- Full command cycle in 2 μs → 8 Mbit/sec
- Look-At-Me (LAM) interrupts computer when some event happens
- Commands follow N.A.F. sequence: slot number, address, function
  - so address specific modules by name/position
  - A and F values perform tasks that are defined by module
  - A often refers to channel number on multiplexed device
  - F might indicate a read, a write, a reset, or other action

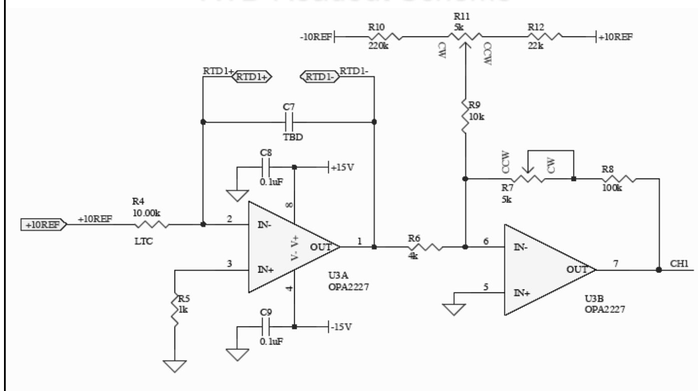
Example Interface: APOLLO

- APOLLO is a lunar ranging apparatus that fires 20 laser pulses per second at a selected lunar reflector, measuring the time-of-flight of photons making the round trip
- Besides the essential function of data collection and apparatus coordination, we wanted remote operation capability
- We also required strict thermal control

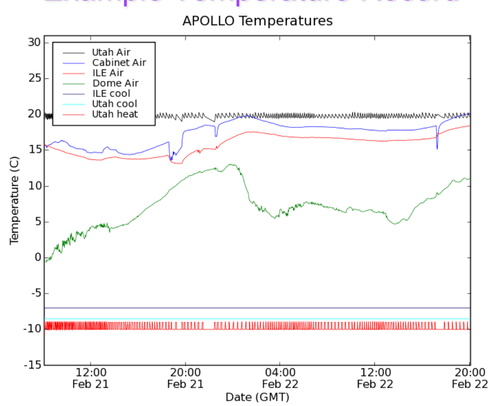
Catalog of APOLLO Interfaces

- Uses a Linux PC (runs for a year at a time, no crashes)
- Two GPIB devices
  - GPS-disciplined clock; actuated optics (mirror tilt, lens focus)
- 5 RS-232 devices
  - motor that spins optic (8N1 @ 57600); laser control (8E1 @ 9600); CCD camera control (8N1 @ 115200); laser power meter (bolometer) (8N1 @ 9600); GPS clock (7E1 @ 9600)
- CAMAC crate with two devices
  - TDC for 10 ps timing; custom module to control timing
  - another device sits passively in crate, no access to dataway
- DAQ card for analog input, digital output
  - analog inputs for RTDs (temperature); flow meters; pulse energy; telescope tilt angle
  - digital outputs for relay control: turning devices on and off
- Parallel port used for additional digital outputs for more relays

RTD Readout Scheme



Example Temperature Record



Reading

- Read 6.7.3; skim 6.7.5; read 6.7.7; 6.7.9