

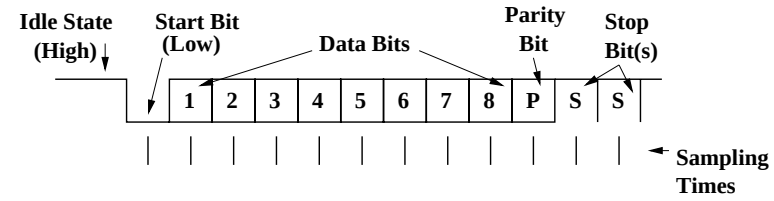

Data Transmission

Data Transmission

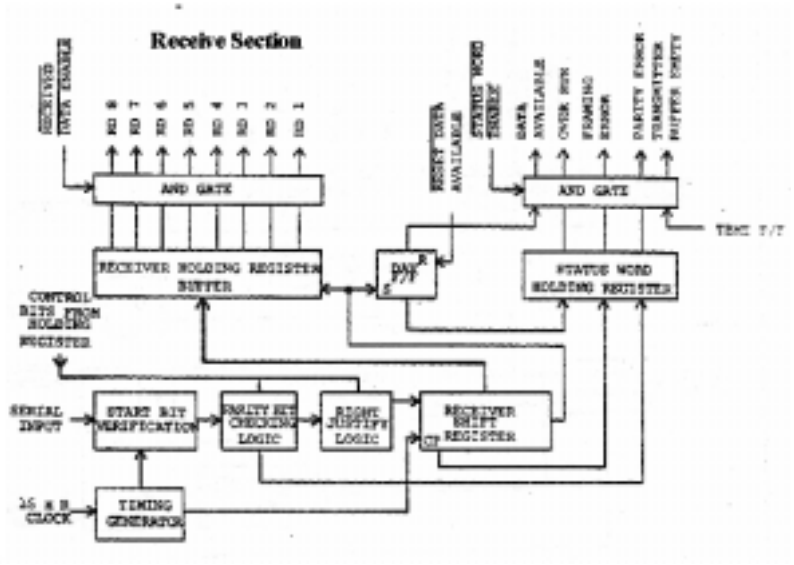
- There are two basic methods.
  - Recover a clock from a serial transmission.
    - This requires a phase lock loop.
    - Examples:
      - network data
      - disk
      - tape
      - GPS
      - Digital TV
    - We will not do this in 6.111.
      - FPGAs are hardwired to use a single clock.
  - Synchronize incoming data to a local clock.
    - Serial data transmission
      - Uses only two wires (or radio and earth ground).
      - Slow – at most one bit per clock period
    - Parallel data transmission
      - Uses at least one wire per bit.
      - Fast – a word (n bits) at a time
      - Need to agree on control signals to know when data is stable

Serial Data Transmission

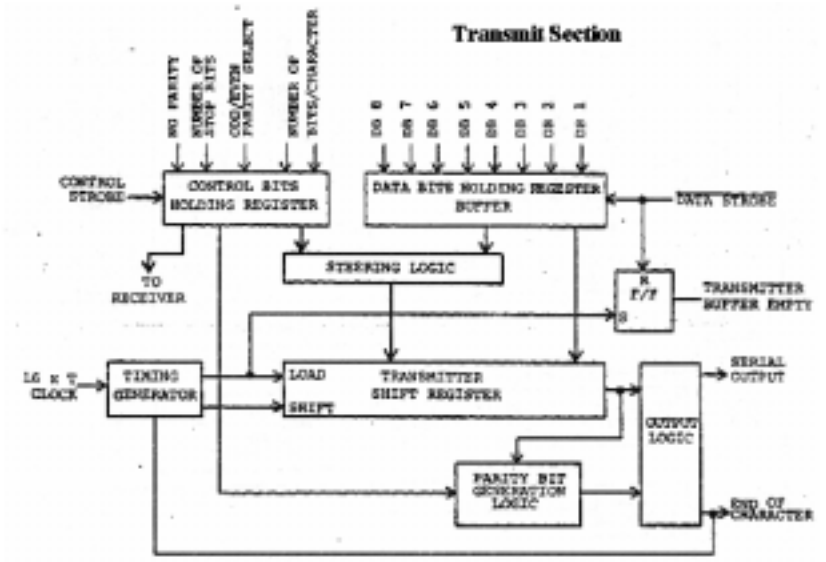
- RS – 232 is a serial interface standard.
  - RS – 232 levels are between
    - - 3v and – 15 v for a logic 1
    - + 3v and + 15 v for a logic 0
- The TTL signal below has an “idle” state of a logic 1.
  - MAXIM 233 has two RS – 232 to TTL and two TTL to RS – 232 level converters.



AY-3-1015D Receive Section

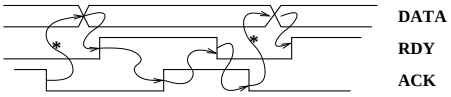


AY-3-1015D Transmit Section



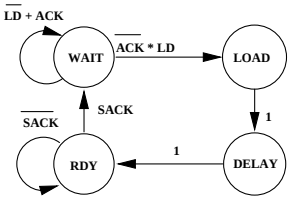
Parallel Transmission

- **Full Handshake – RDY and ACK return to zero.**
  - **Assumes data source and destination have unrelated clocks.**
  - **E.g., the two locations are on separate kits.**
  - **Why not send clock from one kit to another?**

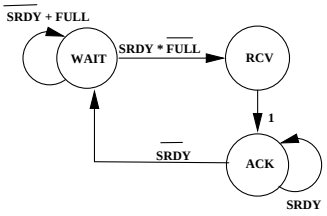


*** and we want to send more data, i..e, LD is true.**

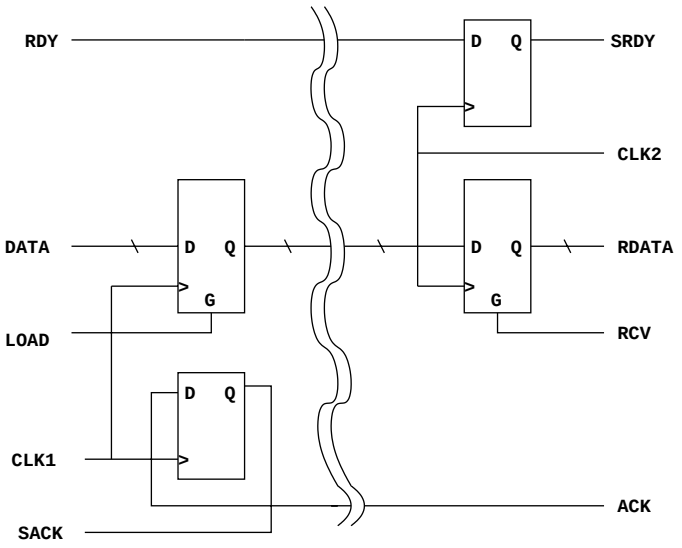
At sending end



At receiving end

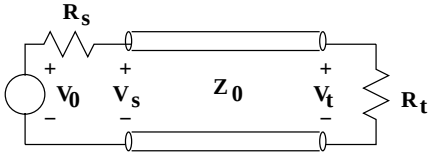


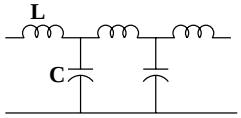
Parallel Interface



Transmission Lines

- Signals travel on wires.
  - Attenuation – losses due to resistance of wires
  - Reflections – affected by terminations





Transmission line has characteristic parameters:

L: Inductance per unit length
C: Capacitance per unit length

$$Z_0 = \sqrt{\frac{L}{C}}$$

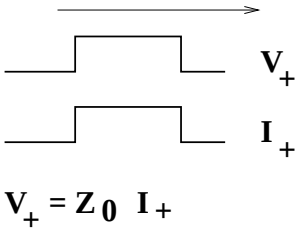
Z_0 : Characteristic Impedance

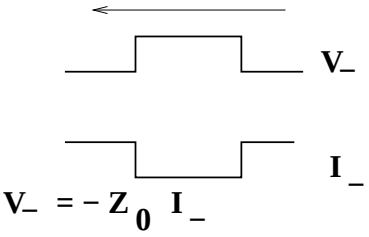
U_0 : Phase Velocity

$$U_0 = \sqrt{\frac{1}{LC}}$$

Signal Propagation

- Pulses travel along the line.
  - Ratio of voltage to current is the “characteristic impedance”.
  - Sign of that ratio is the direction of propagation.
  - Pulses propagate at a velocity < c (speed of light).

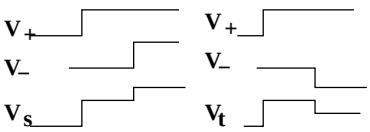




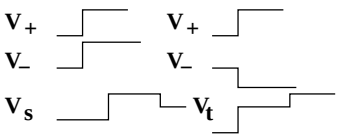
Reflections

- Pulses are absorbed if the receiving end is matched to the characteristic impedance.
  - If the receiving end is not matched then a pulse “reflects”.
  - The sign of the reflection depends on the impedance value relative to the characteristic impedance.

Reflections: $R_t > Z_0$

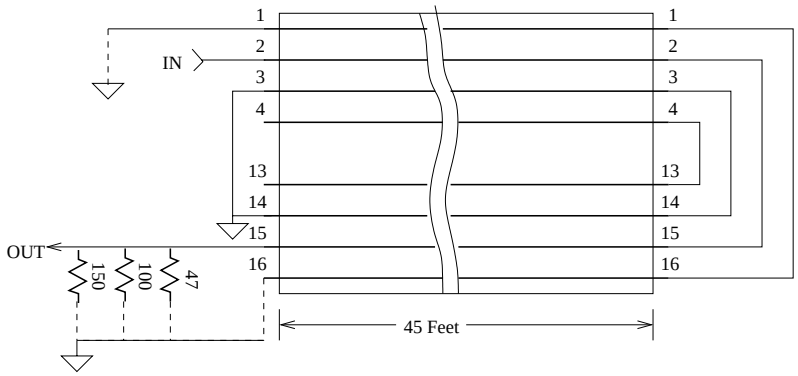


Reflections: $R_t < Z_0$



Characteristic Impedance Demo

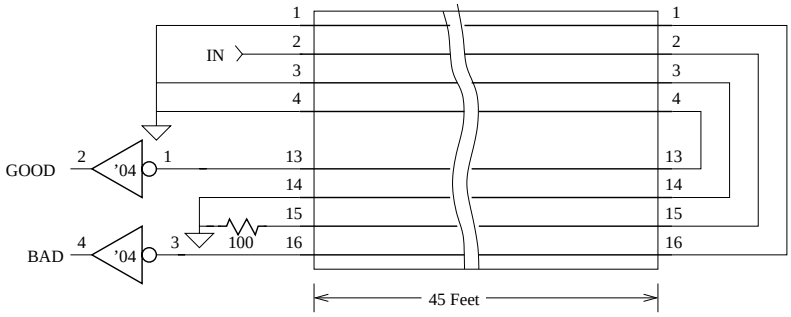
- Reflections depend on the terminating impedance.
  - They can be minimized by terminating correctly, i.e., with the characteristic impedance?
  - Why can't they be eliminated?



Moral: Terminate Wires in Characteristic Impedance

Crosstalk Demo

- Flat ribbon cable – similar to kit interconnect cables
  - The wires are situated right next to each other.
  - They have capacitive and inductive coupling.
- Crosstalk is minimized by alternating signals and grounds.
  - Ground – Signal – Ground – Signal ……



Moral: Alternate Ground and Signal Wires in Cables