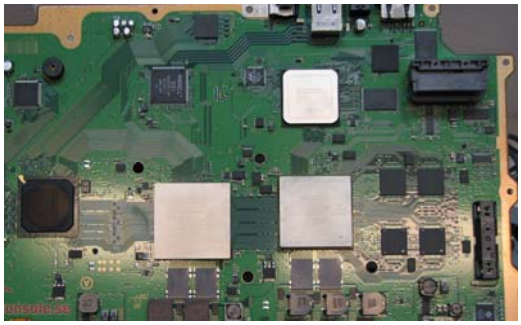
EECS240 – Spring 2010

Lecture 18: High-Speed Link Overview

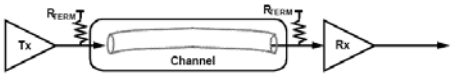
Elad Alon
Dept. of EECS

Links are everywhere…

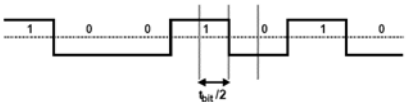


Basic Link Issues

- **Signaling: getting bits from the TX to the RX**



- **Timing: determining which bit is which**



Speed of Light

- **Why is a link (i.e., off-chip I/O) different than on-chip wires?**
  - **Both send info back and forth**
- **Usually model on-chip wires with capacitor**
  - **Sometimes with resistance too**
- **On-chip model works because dimensions << λ**
  - **Not true for off-chip wires…**

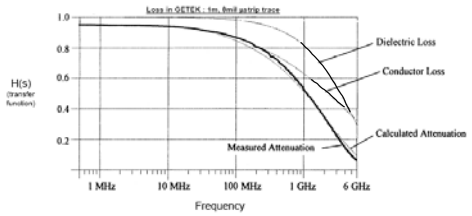
Transmission Lines

- **Wire model when can't ignore *c*:**
- **Properties:**
  - **Delay**
  - **Characteristic impedance**
  - **Energy stored in E, B fields**

Termination and Reflection

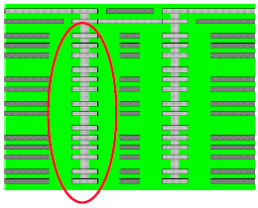
- **Two constraints at any junction:**
  - **Voltage are equal**
  - **Power is conserved**

Loss



- Real T-lines have loss too:
  - Skin loss α $\sqrt{f}$ (in dB)
  - Dielectric loss α f (in dB)

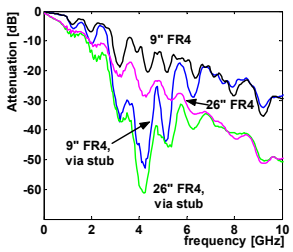
Not Just Material Issues…



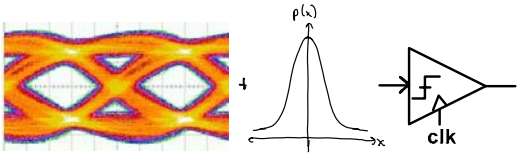
- Energy splits at via
- Via stub looks like a capacitor – reflections

Example Channels

- 20-30dB loss at 3GHz
- How bad is that?
- Two related issues:
  - (1) Noise and min. signal amplitude
  - (2) Intersymbol interference

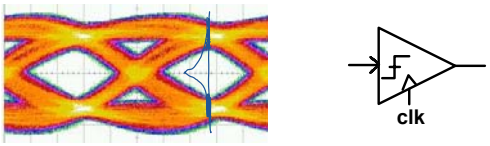


Noise and BER



- RX circuits always have noise
  - If noise is ever larger than the input signal (at sampling point), RX will decode the bit incorrectly
- BER = Bit Error Rate
  - I.e., average # of incorrectly received bits / total transmitted bits

Min. Signal Amplitude



- Min. signal set by noise σ and residual offset:

$$BER = \tfrac{1}{2} erfc\left(\frac{V_{in,ampl} - V_{off}}{\sqrt{2}\sigma_{noise}}\right)$$

- BER = 10^{-12}: $(V_{in,ampl} - V_{off}) = 7\sigma_n$
- BER = 10^{-20}: $(V_{in,ampl} - V_{off}) = 9.25\sigma_n$

So What?

- Why not just hit the RX with a larger signal?
  - (Not a stupid question – this is often what people do)
- Simple (hand-wavy) answers:
  - Transmission line Z usually low (~50Ω)
    - 1V swing → 20mW
  - Larger swing doesn't help with ISI…
    - More next lecture
- Bottom line:
  - If can use lower swing, can get lower power
  - Good application of EE240 material!

Link Circuits: “Current-Mode” TX

- **Often use differential signaling/circuits to reject supply/CM noise:**

Receiver Termination Options

Basic Receiver

Front-end Amp Gain

Front-end Amp Bandwidth