High-Speed Serial Interface Circuits and Systems

Design Exercise 8 – FIR(Finite-Impulse Response) Equalizer
FIR Equalization

Equalization by boosting transition bits (Pre-emphasis)
Equalization by reducing transition bits (De-emphasis)
FIR Equalizer Using CML Driver

Goal: Equalize 2Gbps data transmission

- By time-domain analysis (pulse response)
- 2-tap (one post-cursor) FIR equalizer
**Time-Domain Channel Characteristic**

**Input Source**
- **Input source (Impulse)**
  - vcvs gain: ±1
  - $V_{CM}$: 1.55V
- **Vpulse**
  - -250mV ~ 250mV
  - Period: 1s
  - Delay time: 1ns
  - Rise & fall time: 1ps
  - Pulse width: 499ps

**CML Output Driver**
- Input MOSFETs: 80u/180n
- Tail MOSFETs: 750u/1u
- Load resistors: 50 Ohm
- Reference voltage: 1.3 V (500mV swing)
- $R_{TERM}$: 100 Ohm
Resistor: 1K Ohm
Capacitor: 1n F

VCVS
gain: 1000
Max, Min output voltage: 1.8, 0 V
Simulation Results (Pulse Response)

- Impulse Response
  - 0.5ns spacing each cursor
  - Main-cursor, 1\textsuperscript{st} post-cursor, 2\textsuperscript{nd} post-cursor, 3\textsuperscript{rd} post-cursor, 4\textsuperscript{th} post-cursor
**Random bit stream**
- Period: 1/2Gbps = 500ps
- seed: 1
- vlogic_high, low = 250mV, -250mV → 500mV swing to Rx
- trise, tfall = 20p
Simulation Results (Channel Output)

Closed eye due to channel loss (1u simulation, 0.1u~1u eye diagram)
• Remove 1\textsuperscript{st} post-cursor with 2-tap FIR equalizer
• FIR coefficient calculation
  – Main tap : 500mV (signal swing)
  – Second tap : 117.74mV (= 500mV x (30.19 / 128.2) )
2-Tap FIR Equalizer

- Additional schematic for 2-tap FIR Equalizer

**Delay Element**

- 2nd tap FIR filter
  - Same sizing as CML output driver
  - Carefully connect output (outp, outn)
- Delay element (analogLib⇒delay)
  - 1-period (500ps) delay
  - Make sure ground tied at both input & output
- 2nd tap coefficient (117.74mV)
  - Reference voltage: 1.682V (1.8V – 117.74mV)
Simulation Results (Pulse Response)
Simulation Results (Channel Output)

- ISI compensation by equalization (1u simulation, 0.1u~1u eye diagram)
- Not perfect equalization with 2-tap FIR filter
- Additional taps needed for better equalization