Cyclone V Signaling Sys.

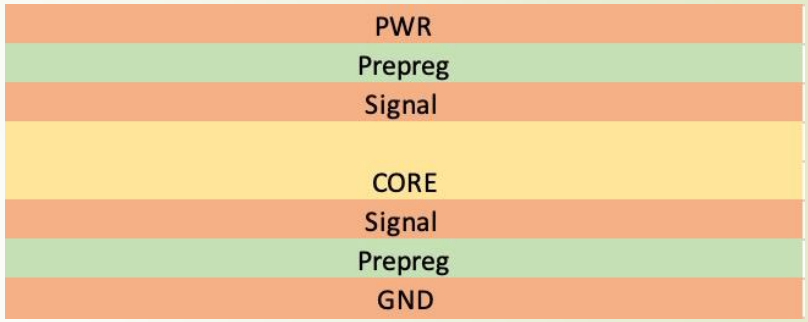
Maxwell Stonham
Dylan Cazares

Cyclone V Chip (5CGXFC5C6F23C6N)

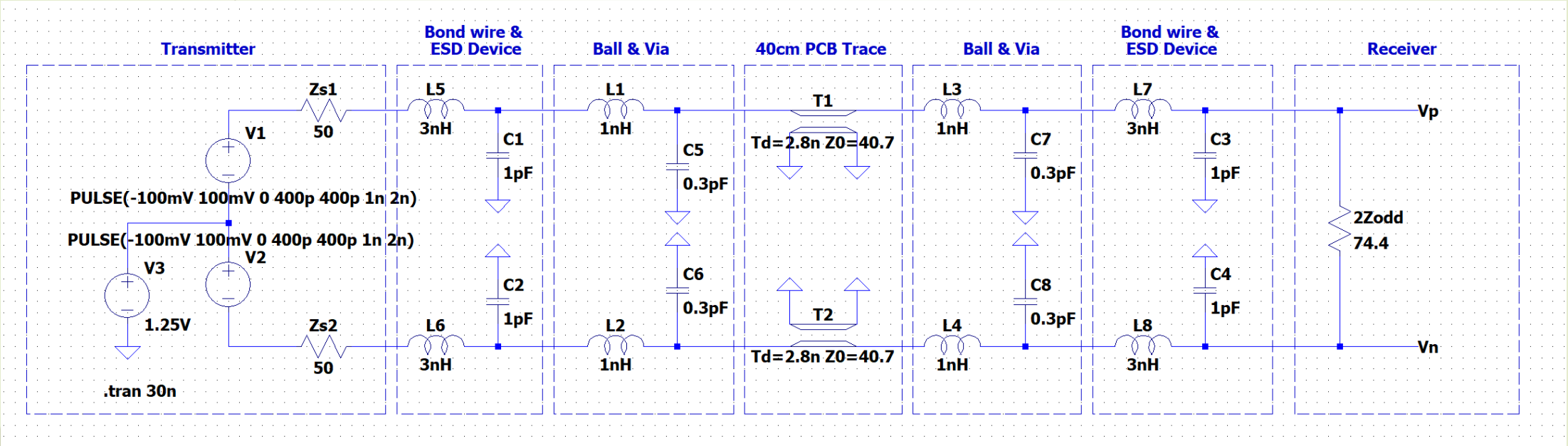
- Bipolar differential signaling system (LVDS)
- Receiver voltage: 1.0V to 1.6V (> 700Mbps), 0V to 1.85V (< 700Mbps)
- Common mode voltage: 1.25V
- 484 Pin FBGA Package
  - Top RX, TX pins: 28
  - Right RX, TX pins: 8
  - Bottom RX, TX pins: 24
- Ball Diameter: 0.34mm
- Ball Pitch: 0.80mm

Board Stack-up and Parameters

- Layer stac-kup: 4 layers
- Width: 3.5mil (0.09mm)
- Spacing (per line): 3.5mil (0.09mm)
- Spacing (per pair): 20.5mil (0.52mm)
- Material: FR-4, Copper Core
- 7628 Prepreg (Dielectric constant = 4.4)
- PCB Thickness = 78.7mil (2mm)
- 35 differential signals on layer 1 and 35 differential signals on layer 2



Overall Design



Noise Budget

	K	mV
Signal Swing (dp-dn)		400
Gross Margin		200
Crosstalk	0.045	18
Reflections	0.045	18
Kn	0.215	86
Receiver offset		40
Gaussian Noise (Vrms)		5
Net Margin		38
V_{SNR}		7.6
Bit Error Rate		2.86×10^{-13}
Mean Time Between Failure		0.222 yrs

Timing System and Budget

- Closed-loop timing system
- Removes skew, still take jitter into consideration

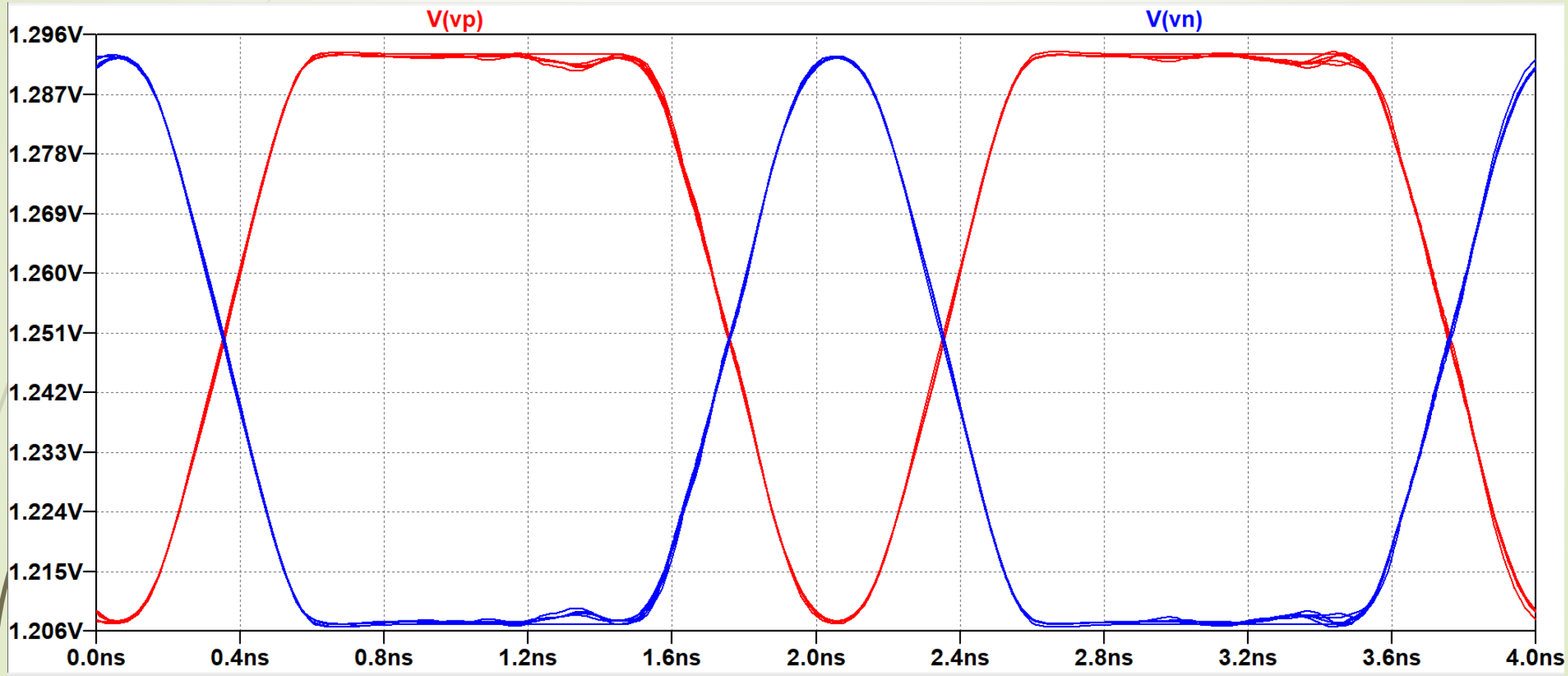
Timing Parameter	Time
Skew	0s
Rise time	400ps
Aperture	20ps
Cycle time	2ns
Delay	1ns
Uncertainty	

Tbit > ta + tr + tu = 420ps

Calculated Parameters

	Value	Equation
Stray Capacitance (C_c)	172pF/m	$C = \frac{we}{d} + \left(\frac{2\pi e}{\ln\left(\frac{s}{h}\right)}\right)$
Coupling Capacitance (C_d)	15pF/m	$C = \frac{8.554pF/m\varepsilon_r A}{d}$
Inductance of Line (L)	285nH/m	$L = \frac{\varepsilon\mu}{C}$
Mutual Inductance (M)	25.83nH/m	$\frac{C_d}{C} = \frac{M}{L}$
Characteristic Impedance (Z_0)	40.7Ω	$Z_0 = \sqrt{\frac{L}{C}}$
Resistance of Line (R)	1.25Ω/m	$R = \frac{\rho L}{A}$
Z_{odd}	37.18Ω	$Z_{odd} = \sqrt{\frac{M-L}{C_d+C}}$
Velocity (v)	$1.4x10^{-8}$	$v = \frac{1}{\sqrt{LC}}$
Transmission Line Delay (t)	2.8ns	$t = \frac{d}{v}$
Inductive Crosstalk Coeffecient (k_{lx})	0.09	$\frac{M}{L}$
Capacitive Crosstalk Coeffecient (k_{cx})	0.09	$\frac{C_d}{C}$
Near end Cross Talk (k_{rx})	0.045	$k_{rx} = \frac{kcx - klx}{4}$
Far-end Cross Talk (k_{fx})	0	$k_{rx} = \frac{kcx - klx}{3}$

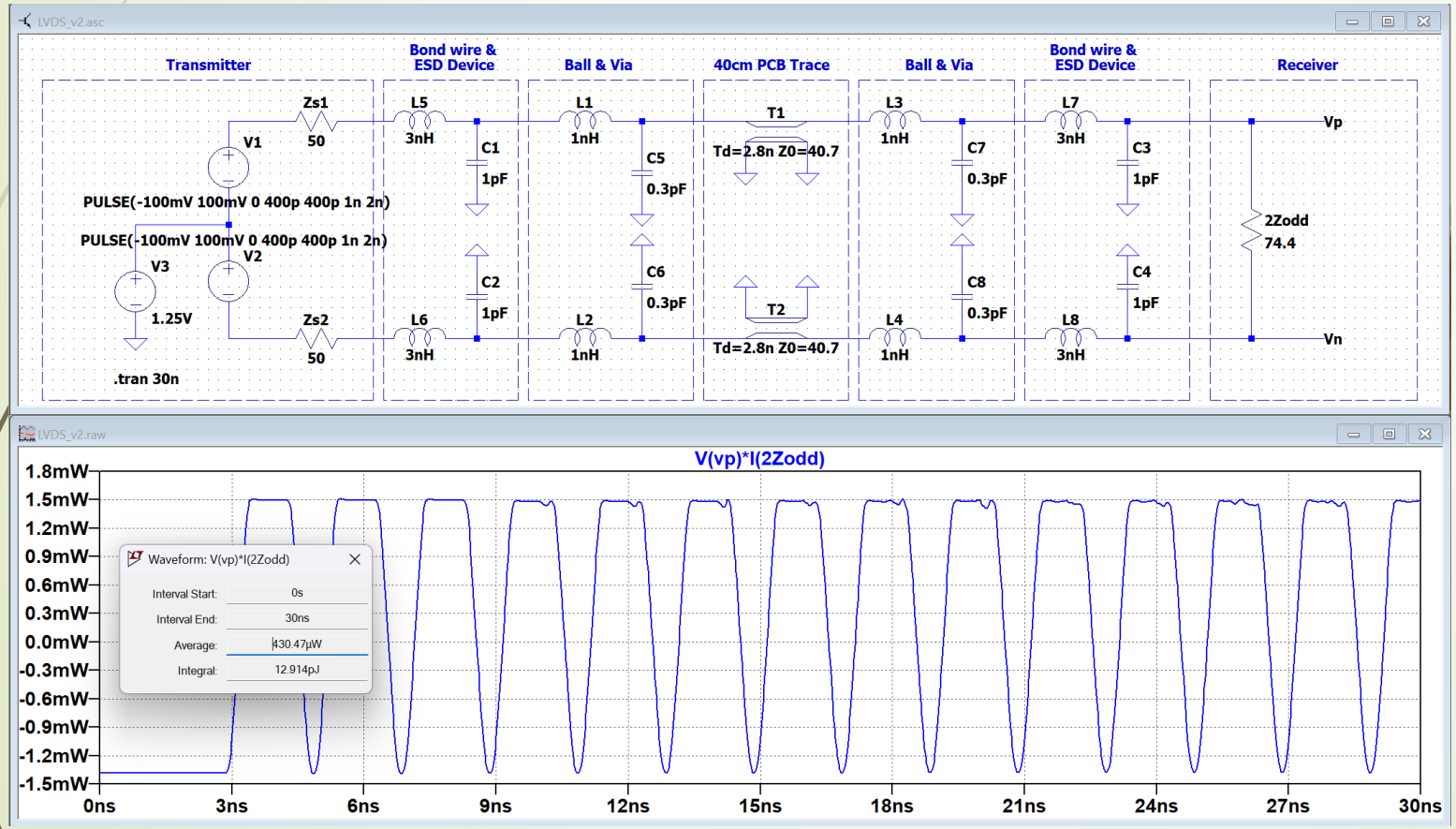
Performance Results

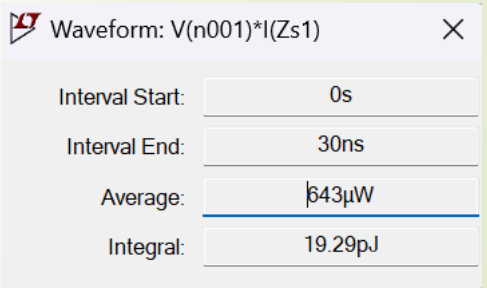


Aperture time = 1.5ns – 0.6ns = 900ps

Power & Cost

- Cyclone V 5CGXFC5C6F23C6N: $244.00
- PCB Cost: $25.40 ($0.37/in^2)





Future Improvements