A Noise-driven Effective Capacitance Method for Victim Driver Linearization in Functional Noise Analysis

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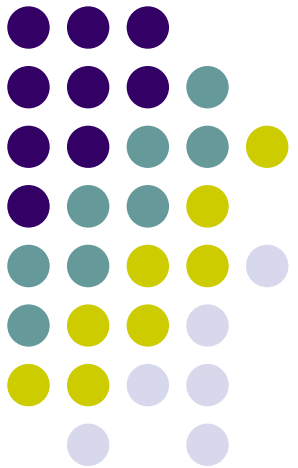

Outline

- Motivation
- Basic idea
  - Driver characterization
  - Ceff flow
- Victim driver linear Thevenin model
- Convergence scenarios
- Experimental results
- Conclusion and future work

Motivation

- To separate the linear/nonlinear analysis for glitch propagation, similar to the idea in timing
- To linearize the victim driver so the worst-case noise peak can be quickly found by superposition
- To avoid the costly victim/aggressor alignment search if nonlinear victim driver model were to be used
- To work efficiently for both RC and RLC interconnect loads
- To work well with multiple-CCC gates

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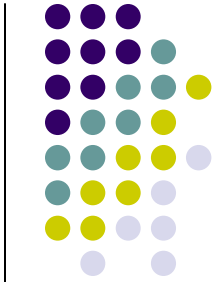
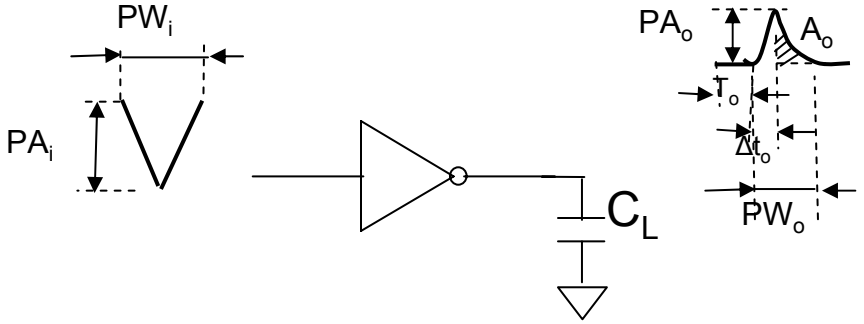
Basic Idea



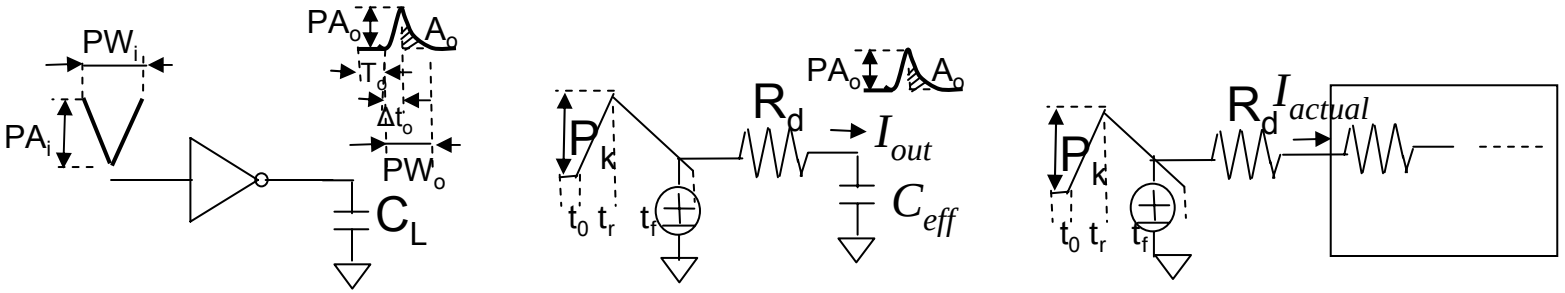
- Pre-characterize noise propagation tables
  - Noise rule: output noise as a function of input noise and output load
  - One time effort
  - Available in existing industry cell libraries
- Run noise-driven effective capacitance procedure to get a linear Thevenin model for the victim driver
- Compute propagation noise and crosstalk noise at sinks using the obtained linear Thevenin model

Driver Characterization



- Victim driver noise propagation tables
  - T_o = f1 (PA_i, PW_i, C_L) (Noise intrinsic delay)
  - Δt_o = f2 (PA_i, PW_i, C_L) (Noise transition to peak time)
  - PA_o= f3 (PA_i, PW_i, C_L) (Noise amplitude)
  - A_o = f4 (PA_i, PW_i, C_L) (Post-peak noise area)
  - TA_o = f5 (PA_i, PW_i, C_L) (Total noise area)
  - PW_o = f6 (PA_i, PW_i, C_L) (Output noise width)
- 3D table for symmetric input waveforms and 4D table for asymmetric input waveforms
- Similar set of information can be found in existing industry cell libraries (e.g. dotlib)
- $I_o(V_i,V_o)$ table for driver last stage, $V_o(V_{i\_last\_stage})$ table and $V_{o\_last\_stage}(V_i)$ table – (not available in dotlib)

Overall C-effective Flow



- Given an input noise and start C_{eff} from total interconnect capacitance
- Choose driver resistance (we fix its value for simplicity)
- Find output noise characteristics from the noise rule table
- Calculate parameters of a triangular voltage source to match the output noise characteristics for simple RC circuit in the middle
- Update C_{eff} to match the average current flowing into the actual interconnect load (pi-model or higher reduced order model)

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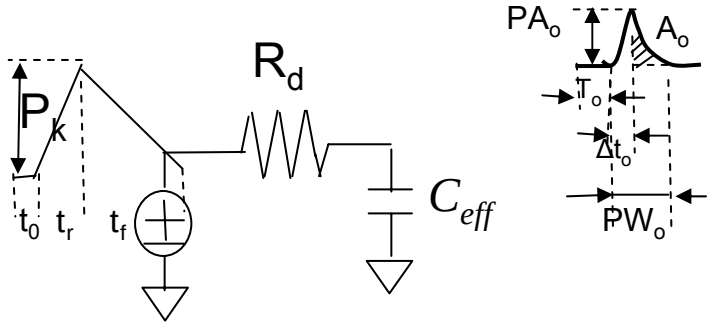
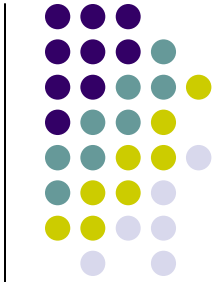
Victim Driver Thevenin Model Parameters



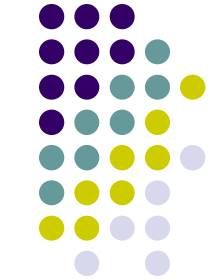
- Driver resistance R_d
- Triangular voltage source with intrinsic delay t_0, rise time t_r, fall time t_f and peak P_k
- For simplicity, set $t_0 = T_o$

Victim Driver Voltage Source Parameters Calculation

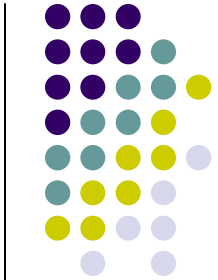


- Three Equations with regard to t_r, t_f and P_k
  - $V_o(\Delta t_o) = PA_o$ (to match output noise peak)
  - $V_o'(\Delta t_o) = 0$ (to match output noise time to peak)
  - $A_o = \int_{\Delta t}^{\infty} V_o(t)\, dt$ (to match post peak noise area)
- Result in
  - Set $T_c = 2A_o/PA_o + \Delta t_o - 2R_dC_{eff}$
  - Solve $f(\mathbf{t_r}) = (1 - e^{\Delta to/RdCeff})\, \mathbf{t_r} + T_c\,(e^{\mathbf{tr}/RdCeff} - 1) = 0$ for t_r (Newton Raphson)
  - $t_f = T_c - t_r$
  - $P_k = PA_o\, t_f / (T_c - \Delta t_o)$

Victim Driver Resistance Calculation



- From sensitivity information in the noise rule
  - $T_c = (2A_o/PA_o) + \Delta t_o - 2R_d C_{eff} = t_r + t_f$
  - Differentiate to C_{eff} to get
    - $R_d = 0.5\ \partial(2A_o/PA_o + \Delta t_o)/\ \partial C_{eff} \Rightarrow 0.5\ \partial PW_o/\ \partial C_{eff}$
    - Valid and useful when output noise is non-negligible
- From the I-V table of the driver (single-CCC or last-stage CCC)
  - Heuristically choose R_d according to the input/output noise height
  - Expect to have higher R_d than the quiet holding resistance
  - Useful when output noise is negligible
- Fix R_d throughout the C_{eff} iterative procedure to simplify the computation
- Same R_d can be used for crosstalk noise analysis



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Three Scenarios of Driver Model Parameters and C_{eff} Convergence

- Case 1
  - General triangular Thevenin voltage source: $t_r>0$, $t_f>0$, $P_k>0$
  - Nonzero C_{eff}, $0<C_{eff}<C_{total}$
- Case 2
  - Very sharp rising transition $t_r=0$
  - Solve $t_f>0$ and $P_k>0$ to match output noise peak and total noise area (another Newton Raphson)
  - Nonzero C_{eff}, $0<C_{eff}<C_{total}$
- Case 3
  - Effective capacitance C_{eff} converges to zero: $C_{eff}=0$
  - Current flowing through the victim driver is close to zero
  - Set $P_k=0$

Note: Considering the switching aggressor driver induced currents to the victim driver, C_{eff} can converge to some negative value

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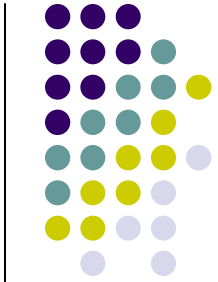
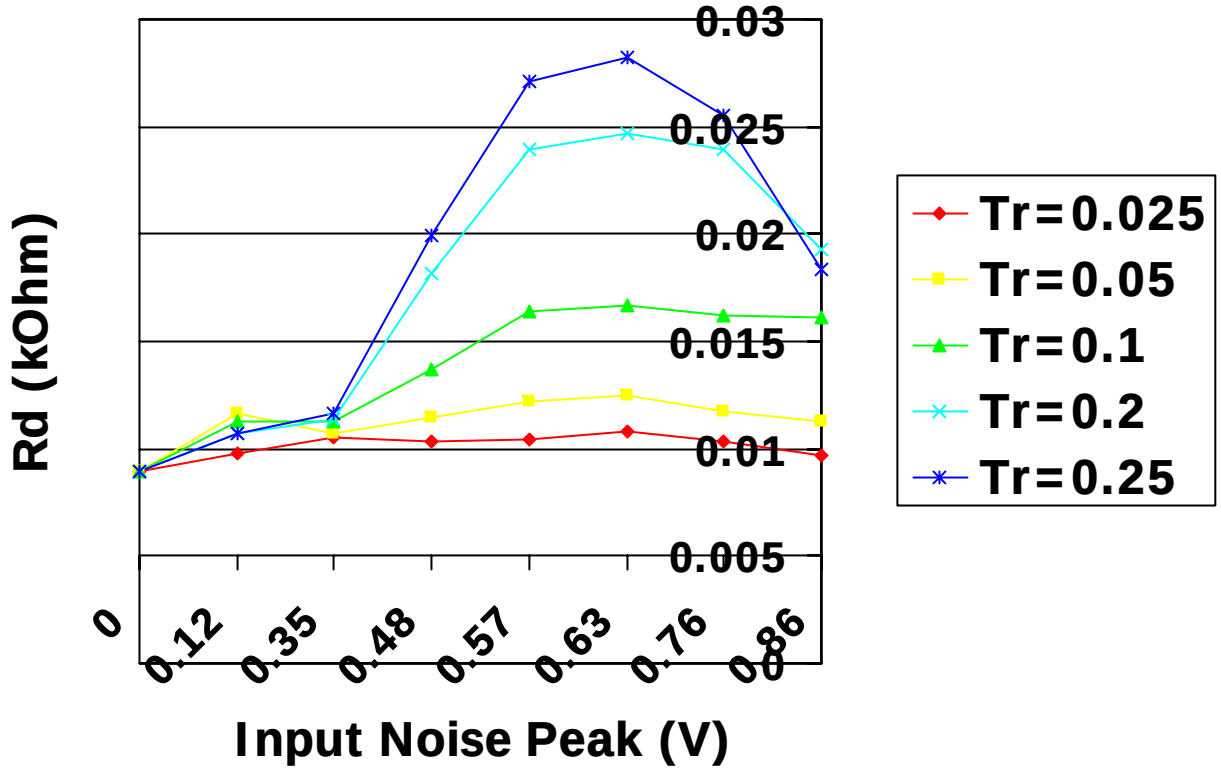
Experiments



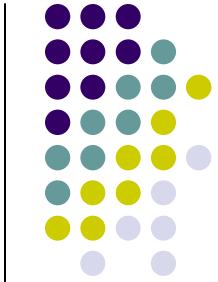
- Drivers are under 130nm technology, Vdd=1.2
- Different sized inverters/buffers drive RC/RLC lines with different lengths
- One aggressor and one victim
- Use Linear aggressor driver with the fastest transition for the technology
- Superposition is used for the combined propagation and crosstalk noise
- Use sensitivity equation to calculate driver resistance
- Compare with PowerSPICE nonlinearly aligned results (true worst-case)

Sensitivity-based Driver Resistance vs. Input Noise Pulse

- 130nm inverter driving C_L=1pF

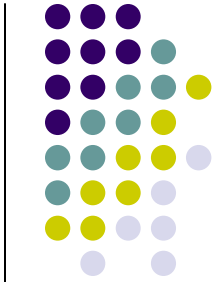


Inverter Driving RC Line (1mm) Propagation Noise Only



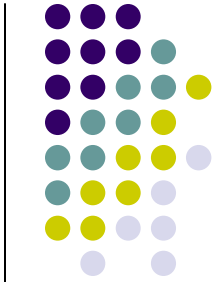
input peak	input width	SPICE output peak	SPICE output area	Ceff output peak	Percent err	Ceff output area	Percent err
0.86	0.025	0.3615	0.01133	0.3817	5.60%	0.01226	8.20%
0.86	0.05	0.5915	0.0289	0.6094	3.00%	0.02914	0.80%
0.86	0.2	1.0162	0.15006	1.0025	1.30%	0.1421	5.30%
0.76	0.025	0.2626	0.00793	0.278	5.90%	0.00842	6.20%
0.76	0.05	0.4318	0.01979	0.4538	5.10%	0.02038	3.00%
0.76	0.2	0.8391	0.10977	0.8366	0.30%	0.10707	2.50%
0.63	0.025	0.1509	0.00444	0.159	5.40%	0.00463	4.30%
0.63	0.05	0.2396	0.01032	0.2543	6.10%	0.01069	3.60%
0.63	0.2	0.479	0.05487	0.4896	2.20%	0.05685	3.60%
0.57	0.025	0.1128	0.0033	0.1169	3.60%	0.00336	1.80%
0.57	0.05	0.1713	0.00732	0.1807	5.50%	0.00744	1.60%
0.57	0.2	0.3205	0.03584	0.3312	3.30%	0.03804	6.10%
0.48	0.025	0.0711	0.00205	0.0717	0.80%	0.00204	0.50%
0.48	0.05	0.1018	0.00431	0.1048	2.90%	0.00431	0.00%
0.48	0.2	0.1602	0.01866	0.1667	4.10%	0.01974	5.80%
0.35	0.025	0.0303	0.00085	0.0302	0.30%	0.00084	1.20%
0.35	0.05	0.0425	0.00173	0.043	1.20%	0.00171	1.20%
0.35	0.2	0.0613	0.00704	0.0623	1.60%	0.00739	5.00%
0.12	0.025	0.0013	0.00004	0		0	
0.12	0.05	0.0017	0.00008	0.002	17.60%	0.00009	12.50%
0.12	0.2	0.0023	0.00032	0.0027	17.40%	0.00039	21.90%

Inverter Driving RC Line (1mm) Propagation + Crosstalk Noise



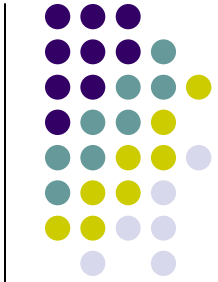
input peak	input width	SPICE output peak	SPICE output area	Ceff output peak	Percent err	Ceff output area	Percent err
0.86	0.025	0.5921	0.02131	0.534	9.80%	0.0186	12.70%
0.86	0.05	0.8247	0.04147	0.761	7.70%	0.0355	14.40%
0.86	0.2	1.2019	0.16232	1.154	4.00%	0.1485	8.50%
0.76	0.025	0.4868	0.0172	0.439	9.80%	0.0155	9.90%
0.76	0.05	0.6701	0.03188	0.615	8.20%	0.0274	14.10%
0.76	0.2	1.0538	0.12521	0.998	5.30%	0.1141	8.90%
0.63	0.025	0.3569	0.01263	0.337	5.60%	0.0132	4.50%
0.63	0.05	0.4684	0.02068	0.433	7.60%	0.0193	6.70%
0.63	0.2	0.7191	0.07108	0.668	7.10%	0.0655	7.90%
0.57	0.025	0.3054	0.01093	0.297	2.80%	0.0122	11.60%
0.57	0.05	0.3862	0.01656	0.361	6.50%	0.0162	2.20%
0.57	0.2	0.5587	0.05049	0.511	8.50%	0.0468	7.30%
0.48	0.025	0.2441	0.009	0.246	0.80%	0.0103	14.40%
0.48	0.05	0.2877	0.01203	0.279	3.00%	0.0125	3.90%
0.48	0.2	0.3698	0.0292	0.341	7.80%	0.028	4.10%
0.35	0.025	0.1874	0.00728	0.183	2.30%	0.0073	0.30%
0.35	0.05	0.2027	0.00836	0.196	3.30%	0.0082	1.90%
0.35	0.2	0.2266	0.01418	0.216	4.70%	0.0138	2.70%
0.12	0.025	0.1514	0.00622	0.162	7.00%	0.0072	15.80%
0.12	0.05	0.1519	0.00629	0.164	8.00%	0.0073	16.10%
0.12	0.2	0.1527	0.00656	0.165	8.10%	0.0076	15.90%

Inverter Driving RLC Line (5mm) Propagation Noise Only



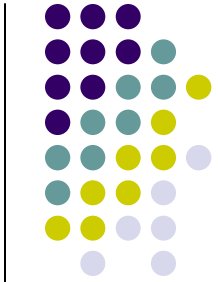
input peak	input width	SPICE output peak	SPICE output area	Ceff output peak	Percent err	Ceff output area	Percent err
0.86	0.025	0.2943	0.01349	0.2919	0.80%	0.01444	7.00%
0.86	0.05	0.426	0.02865	0.4442	4.30%	0.03282	14.60%
0.86	0.2	0.9249	0.14409	0.9058	2.10%	0.14219	1.30%
0.76	0.025	0.2118	0.00957	0.2168	2.40%	0.01041	8.80%
0.76	0.05	0.3187	0.02025	0.3395	6.50%	0.02356	16.30%
0.76	0.2	0.7139	0.10198	0.739	3.50%	0.10739	5.30%
0.63	0.025	0.1206	0.00516	0.1182	2.00%	0.00544	5.40%
0.63	0.05	0.1729	0.01075	0.1877	8.60%	0.01225	14.00%
0.63	0.2	0.3862	0.05064	0.4188	8.40%	0.05709	12.70%
0.57	0.025	0.0847	0.00366	0.0838	1.10%	0.00381	4.10%
0.57	0.05	0.1184	0.00752	0.1297	9.50%	0.00839	11.60%
0.57	0.2	0.2583	0.03373	0.2811	8.80%	0.03814	13.10%
0.48	0.025	0.0474	0.00213	0.0482	1.70%	0.00215	0.90%
0.48	0.05	0.0664	0.00431	0.0708	6.60%	0.00456	5.80%
0.48	0.2	0.1332	0.0181	0.1441	8.20%	0.01966	8.60%
0.35	0.025	0.019	0.00085	0.0196	3.20%	0.00086	1.20%
0.35	0.05	0.0269	0.00171	0.0277	3.00%	0.00175	2.30%
0.35	0.2	0.0514	0.00692	0.0547	6.40%	0.00728	5.20%
0.12	0.025	0.001	0.00004	0		0	
0.12	0.05	0.0012	0.00008	0.0013	8.30%	0.00009	12.50%
0.12	0.2	0.002	0.00032	0.0024	20.00%	0.00038	18.70%

Inverter Driving RLC Line (5mm) Propagation + Crosstalk Noise



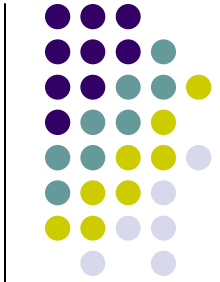
		SPICE	SPICE	Ceff	Percent	Ceff	Percent
input	input	output	output	output		output	
peak	width	peak	area	peak	err	area	err
0.86	0.025	0.6092	0.03	0.6064	0.50%	0.03071	2.40%
0.86	0.05	0.7414	0.04548	0.7586	2.30%	0.0491	8.00%
0.86	0.2	1.2724	0.16873	1.2202	4.10%	0.15847	6.10%
0.76	0.025	0.546	0.0288	0.5335	2.30%	0.02728	5.30%
0.76	0.05	0.6339	0.03695	0.6562	3.50%	0.04043	9.40%
0.76	0.2	1.0682	0.12659	1.0556	1.20%	0.12426	1.80%
0.63	0.025	0.473	0.02364	0.4412	6.70%	0.0241	1.90%
0.63	0.05	0.4881	0.02731	0.5106	4.60%	0.03091	13.20%
0.63	0.2	0.7374	0.0727	0.7417	0.60%	0.07575	4.20%
0.57	0.025	0.4352	0.02163	0.4104	5.70%	0.02366	9.40%
0.57	0.05	0.4369	0.02679	0.4564	4.50%	0.02823	5.40%
0.57	0.2	0.5985	0.05381	0.6077	1.50%	0.05799	7.80%
0.48	0.025	0.3828	0.01934	0.3737	2.40%	0.02165	11.90%
0.48	0.05	0.3833	0.02215	0.3963	3.40%	0.02405	8.60%
0.48	0.2	0.4581	0.03597	0.4697	2.50%	0.03915	8.80%
0.35	0.025	0.3393	0.0175	0.3349	1.30%	0.01736	0.80%
0.35	0.05	0.3416	0.01814	0.343	0.40%	0.01825	0.60%
0.35	0.2	0.3689	0.02374	0.3699	0.30%	0.02377	0.10%
0.12	0.025	0.3161	0.01647	0.3172	0.30%	0.01702	3.30%
0.12	0.05	0.3157	0.01649	0.3185	0.90%	0.01711	3.80%
0.12	0.2	0.3169	0.01677	0.3196	0.90%	0.0174	3.80%

Buffer Driving RC Line (1mm) Propagation Noise Only



input peak	input width	SPICE output peak	SPICE output area	Ceff output peak	Percent err	Ceff output area	Percent err
0.86	0.025	0.2297	0.00554	0.2335	1.50%	0.00591	4.00%
0.86	0.05	0.5159	0.01746	0.5263	2.00%	0.01752	0.50%
0.86	0.1	0.8548	0.04617	0.8247	3.60%	0.04201	9.30%
0.86	0.2	1.0873	0.10281	1.0333	5.00%	0.08654	15.90%
0.86	0.25	1.1283	0.12993	1.0765	4.60%	0.10714	17.60%
0.76	0.025	0.0813	0.00186	0.0876	7.40%	0.00202	0.50%
0.76	0.05	0.2028	0.00588	0.2147	5.70%	0.00622	3.20%
0.76	0.1	0.4141	0.01724	0.4292	3.60%	0.01769	1.70%
0.76	0.2	0.6892	0.04593	0.6804	1.30%	0.04418	4.10%
0.76	0.25	0.7801	0.06139	0.7597	2.70%	0.05798	5.80%
0.63	0.025	0.0158	0.00036	0		0	
0.63	0.05	0.0329	0.0009	0.0344	3.60%	0.00093	11.40%
0.63	0.1	0.055	0.00204	0.0591	6.90%	0.00214	2.30%
0.63	0.2	0.0789	0.00438	0.0877	10.70%	0.00481	6.40%
0.63	0.25	0.0865	0.00555	0.0977	12.60%	0.00626	9.80%
0.57	0.025	0.0062	0.00014	0		0	
0.57	0.05	0.0123	0.00034	0.0135	7.10%	0.00038	22.40%
0.57	0.1	0.0199	0.00075	0.0221	9.40%	0.00081	9.00%
0.57	0.2	0.0275	0.00155	0.0311	11.90%	0.00175	2.90%
0.57	0.25	0.0297	0.00195	0.0339	13.00%	0.00226	7.60%

Buffer Driving RC Line (1mm) Propagation + Crosstalk Noise



		SPICE	SPICE	Ceff	Percent	Ceff	Percent
input	input	output	output	output		output	
peak	width	peak	area	peak	err	area	err
0.86	0.025	0.4324	0.01354	0.3833	11.40%	0.01213	10.40%
0.86	0.05	0.7378	0.02782	0.6761	8.40%	0.02373	14.70%
0.86	0.1	1.0527	0.05777	0.9746	7.40%	0.04822	16.50%
0.86	0.2	1.2599	0.11387	1.1832	6.10%	0.09276	18.50%
0.86	0.25	1.2986	0.14042	1.2263	5.60%	0.11335	19.30%
0.76	0.025	0.2565	0.00874	0.2365	7.80%	0.00817	6.50%
0.76	0.05	0.4086	0.01425	0.3635	11.00%	0.01237	13.20%
0.76	0.1	0.6367	0.02812	0.578	9.20%	0.02383	15.30%
0.76	0.2	0.9054	0.05914	0.8292	8.40%	0.05032	14.90%
0.76	0.25	0.9896	0.07501	0.9085	8.20%	0.06413	14.50%
0.63	0.025	0.1686	0.00662	0.1573	6.70%	0.00676	2.10%
0.63	0.05	0.1894	0.00732	0.1916	1.20%	0.00769	5.10%
0.63	0.1	0.2175	0.00875	0.2164	0.50%	0.0089	1.70%
0.63	0.2	0.2492	0.0116	0.245	1.70%	0.01157	0.30%
0.63	0.25	0.2594	0.01298	0.255	1.70%	0.01302	0.30%
0.57	0.025	0.1572	0.00635	0.1552	1.30%	0.00661	4.10%
0.57	0.05	0.1644	0.00661	0.1687	2.60%	0.00698	5.60%
0.57	0.1	0.1733	0.0071	0.1773	2.30%	0.00741	4.40%
0.57	0.2	0.1822	0.00802	0.1863	2.30%	0.00836	4.20%
0.57	0.25	0.1848	0.00845	0.1891	2.30%	0.00886	4.90%

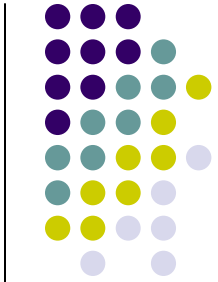
Buffer Driving RLC Line (5mm) Propagation Noise Only

		SPICE	SPICE	Ceff	Percent	Ceff	Percent
input	input	output	output	output		output	
peak	width	peak	area	peak	err	area	err
0.86	0.025	0.1967	0.00738	0.1895	3.70%	0.00716	3.00%
0.86	0.05	0.4167	0.02023	0.3826	8.20%	0.02004	0.90%
0.86	0.1	0.5903	0.04438	0.5441	7.80%	0.04363	1.70%
0.86	0.2	0.8656	0.09663	0.8052	7.00%	0.08623	10.80%
0.86	0.25	1.004	0.12539	0.8954	10.80%	0.10671	14.90%
0.76	0.025	0.0719	0.00221	0.0773	7.50%	0.00229	3.60%
0.76	0.05	0.1632	0.00716	0.1595	2.30%	0.00727	1.50%
0.76	0.1	0.3189	0.01887	0.3162	0.80%	0.02016	6.80%
0.76	0.2	0.496	0.04399	0.5113	3.10%	0.0479	8.90%
0.76	0.25	0.5697	0.05736	0.6082	6.80%	0.06179	7.70%
0.63	0.025	0.0133	0.00036	0		0	
0.63	0.05	0.0201	0.00092	0.0219	9.00%	0.00093	1.10%
0.63	0.1	0.0361	0.00208	0.0391	8.30%	0.00222	6.70%
0.63	0.2	0.055	0.00441	0.0607	10.40%	0.00505	14.50%
0.63	0.25	0.0623	0.00558	0.0685	10.00%	0.00645	15.60%
0.57	0.025	0.0055	0.00014	0		0	
0.57	0.05	0.0075	0.00035	0		0	
0.57	0.1	0.0127	0.00075	0.0143	12.60%	0.00083	10.70%
0.57	0.2	0.019	0.00155	0.0209	10.00%	0.0018	16.10%
0.57	0.25	0.0213	0.00195	0.0241	13.10%	0.00229	17.40%

Buffer Driving RLC Line (5mm) Propagation + Crosstalk Noise

		SPICE	SPICE	Ceff	Percent	Ceff	Percent
input	input	output	output	output		output	
peak	width	peak	area	peak	err	area	err
0.86	0.025	0.5401	0.02519	0.5037	6.70%	0.0234	7.10%
0.86	0.05	0.7314	0.03651	0.6969	4.70%	0.03628	0.60%
0.86	0.1	0.9067	0.06102	0.8584	5.30%	0.05987	1.90%
0.86	0.2	1.2117	0.11763	1.1195	7.60%	0.10248	12.90%
0.86	0.25	1.3462	0.14721	1.2097	10.10%	0.12295	16.50%
0.76	0.025	0.4138	0.01919	0.3907	5.60%	0.01833	4.50%
0.76	0.05	0.4793	0.02547	0.4729	1.30%	0.02331	8.50%
0.76	0.1	0.634	0.03521	0.6297	0.70%	0.0362	2.80%
0.76	0.2	0.8165	0.0615	0.8247	1.00%	0.06394	4.00%
0.76	0.25	0.9119	0.07694	0.9217	1.10%	0.07783	1.20%
0.63	0.025	0.331	0.01659	0.3159	4.60%	0.01667	0.50%
0.63	0.05	0.3391	0.01729	0.3378	0.40%	0.01761	1.90%
0.63	0.1	0.3506	0.01823	0.355	1.30%	0.01889	3.60%
0.63	0.2	0.3704	0.02067	0.3766	1.70%	0.02172	5.10%
0.63	0.25	0.3781	0.0219	0.3844	1.70%	0.02312	5.60%
0.57	0.025	0.3213	0.01631	0.3181	1.00%	0.01726	5.80%
0.57	0.05	0.3238	0.01657	0.3181	1.80%	0.01726	4.20%
0.57	0.1	0.3272	0.01688	0.3324	1.60%	0.01809	7.20%
0.57	0.2	0.334	0.01774	0.339	1.50%	0.01907	7.50%
0.57	0.25	0.3364	0.01817	0.3422	1.70%	0.01956	7.60%

Inverter Driving RLC Line (2.5mm) Propagation Noise Only

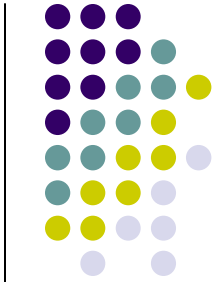


input peak	input width	output peak	output area	output peak	err	output area	err
0.86	0.025	0.5403	0.01388	0.4844	10.30%	0.01447	4.30%
0.86	0.05	0.7511	0.03057	0.7016	6.60%	0.03176	3.90%
0.86	0.2	1.1176	0.1518	1.093	2.20%	0.14173	6.60%
0.76	0.025	0.415	0.00991	0.3663	11.70%	0.01025	3.40%
0.76	0.05	0.5618	0.02127	0.5422	3.50%	0.02323	9.20%
0.76	0.2	0.9649	0.11343	0.9379	2.80%	0.11057	2.50%
0.63	0.025	0.2377	0.00546	0.2129	10.40%	0.00546	0.00%
0.63	0.05	0.3197	0.01122	0.3008	5.90%	0.01209	7.80%
0.63	0.2	0.5718	0.05738	0.5754	0.60%	0.061	6.30%
0.57	0.025	0.1667	0.00395	0.154	7.60%	0.00382	3.30%
0.57	0.05	0.2234	0.0079	0.2096	6.20%	0.00826	4.60%
0.57	0.2	0.3776	0.03697	0.3978	5.30%	0.04163	12.60%
0.48	0.025	0.0934	0.00242	0.0881	5.70%	0.00214	11.60%
0.48	0.05	0.1225	0.00463	0.1166	4.80%	0.00449	3.00%
0.48	0.2	0.1785	0.01892	0.19	6.40%	0.02078	9.80%
0.35	0.025	0.0387	0.00114	0.0369	4.70%	0.00088	22.80%
0.35	0.05	0.0493	0.002	0.0483	2.00%	0.00179	10.50%
0.35	0.2	0.0665	0.00725	0.07	5.30%	0.00786	8.40%

Inverter Driving RLC Line (2.5mm) Propagation + Crosstalk Noise

input peak	input width	SPICE output peak	SPICE output area	Ceff output peak	Percent err	Ceff output area	Percent err
0.86	0.025	0.7643	0.01965	0.7281	4.70%	0.02087	6.20%
0.86	0.05	1.0008	0.03926	0.9511	5.00%	0.0393	0.10%
0.86	0.2	1.3531	0.16088	1.3331	1.50%	0.14752	8.30%
0.76	0.025	0.6283	0.01594	0.6092	3.00%	0.0165	3.50%
0.76	0.05	0.8106	0.02934	0.7912	2.40%	0.03066	4.50%
0.76	0.2	1.2166	0.12429	1.1898	2.20%	0.11863	4.60%
0.63	0.025	0.4527	0.0111	0.4551	0.50%	0.01158	4.30%
0.63	0.05	0.5478	0.01807	0.5487	0.20%	0.0193	6.80%
0.63	0.2	0.8309	0.06888	0.8358	0.60%	0.07125	3.40%
0.57	0.025	0.3789	0.00938	0.3954	4.40%	0.00981	4.60%
0.57	0.05	0.4442	0.01415	0.4565	2.80%	0.01527	7.90%
0.57	0.2	0.6408	0.04715	0.6583	2.70%	0.05191	10.10%
0.48	0.025	0.2965	0.00759	0.3281	10.70%	0.00789	4.00%
0.48	0.05	0.3352	0.01017	0.3607	7.60%	0.01096	7.80%
0.48	0.2	0.4219	0.02636	0.4438	5.20%	0.02928	11.10%

Effective Capacitance And Its Convergence



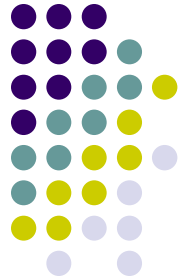
	input peak	input width	Total cap	Effective cap	Num itr
	0.86	0.025	0.2	0.127	5
	0.86	0.05	0.2	0.171	3
	0.86	0.2	0.2	0.184	3
	0.48	0.025	0.2	0.117	5
RC	0.48	0.05	0.2	0.169	3
	0.48	0.2	0.2	0.184	3
	0.12	0.025	0.2	0	1
	0.12	0.05	0.2	0.172	3
	0.12	0.2	0.2	0.186	2
	0.86	0.025	0.9	0.266	6
	0.86	0.05	0.9	0.48	5
	0.86	0.2	0.9	0.698	4
	0.48	0.025	0.9	0.237	5
RLC	0.48	0.05	0.9	0.488	4
	0.48	0.2	0.9	0.706	3
	0.12	0.025	0.9	0.001	1
	0.12	0.05	0.9	0.532	3
	0.12	0.2	0.9	0.794	3

Inverters driving 1mm RC lines and 5mm RLC lines

Outline

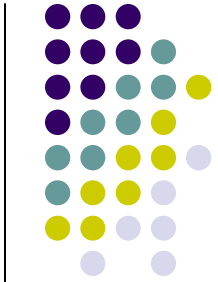
- Motivation
- Basic idea
  - Driver characterization
  - Ceff flow
- Victim driver linear Thevenin model
- Convergence discussions
- Experimental results
- Conclusion and future work

Conclusion And Future Work



- Presented a noise-driven effective capacitance method to linearize the victim driver
- Both the propagation and combined noise results match closely to PowerSPICE results
- Can handle both RC and RLC interconnects efficiently
- Will use behavioral model for fast on-the-fly evaluation of noise rules of the victim driver to remove dependency on the limitation of the noise propagation table
  - Wave shape dependency
  - Negative capacitance limitation
- Will run more testcases with higher crosstalk noise

Acknowledgement



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