Delay Model for Static CMOS Gates Considering Single Input Multiple Transistor Switching

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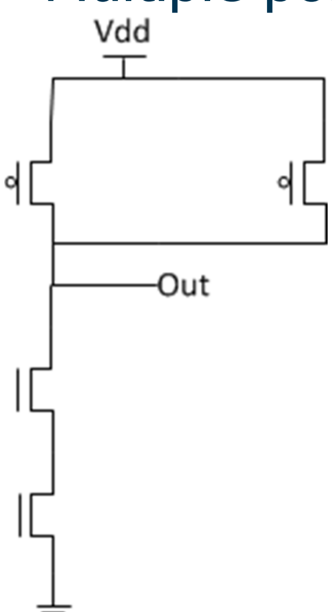
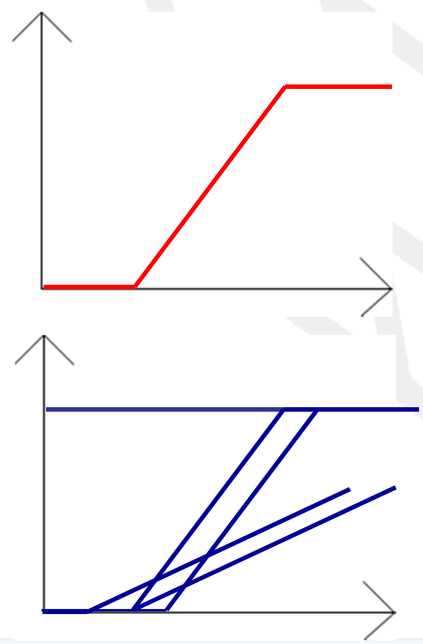
Motivation

- The standard cell methodology is widely used
  - Finite set of cells
    - Impact circuit performance
  - Electrical behavior of the cells must be known
    - Electrical simulations
- Library free methodology
  - Cells can be generated on-the-fly
  - How to know the electrical behavior?
    - Electrical simulations become prohibitive
    - Analytical models are alternatives

Analytical delay models

- Deriving analytical delay model is a hard task
  - Non-linear circuits
  - Several second-order efffects:
    - Channel length modulation, drain induced barrier lowering, body effect...
  - Multiple possible switching scenarios

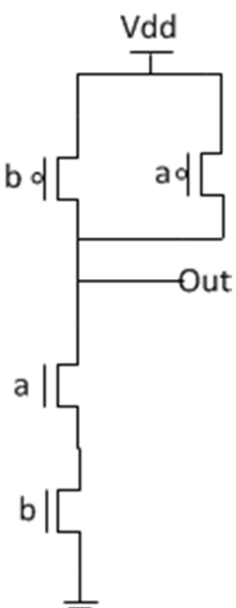


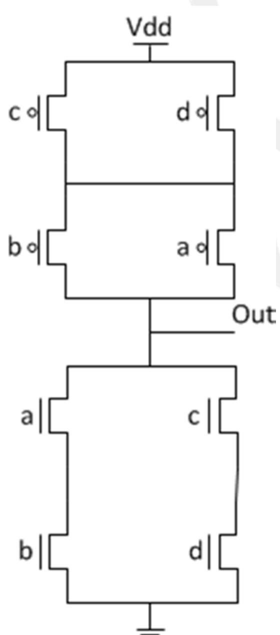


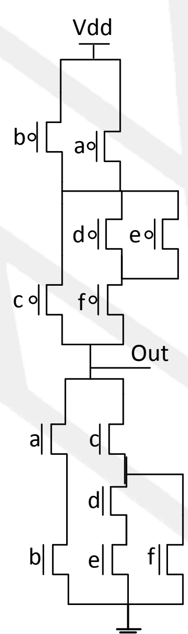
Diferrent transition time and start time

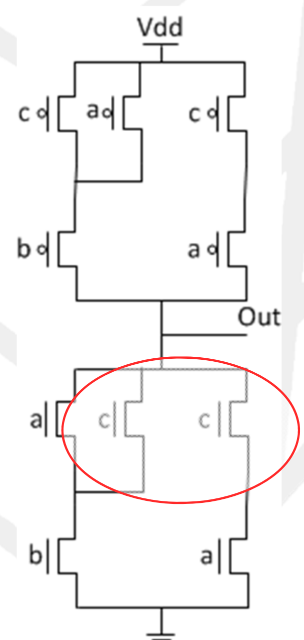
Analytical delay models

- Timing analysis can consider that only one input switches
  - Most models assume that only one NMOS and one PMOS switch
  - Valid assumption for common gates in libraries





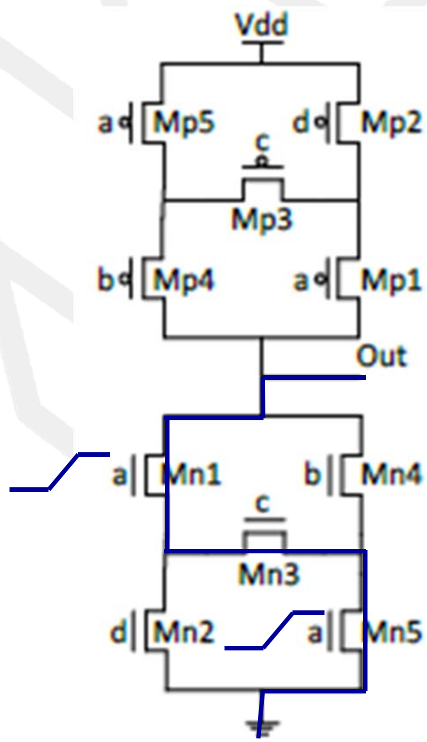




Still valid assumption...

Work proposal

- In some cases, the impact of simultaneous switching is important
- This work proposes an analytical delay model to consider two stacked transistor switching simultaneously
  - Extension to previous work

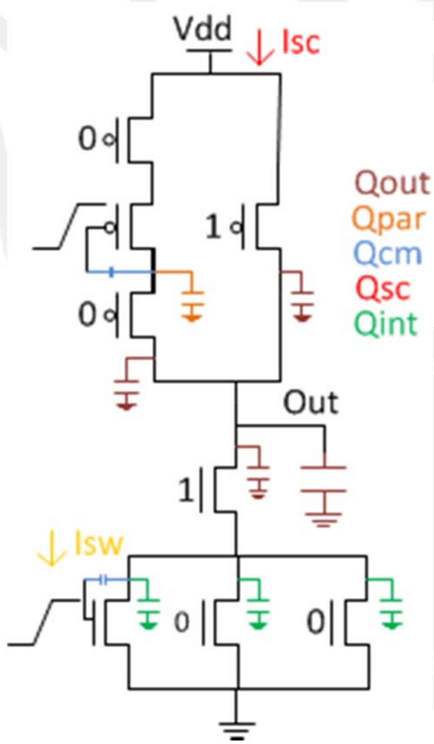


Deriving an analytical delay model

- Analytical delay models estimate
  - Required charge to cause the output voltage drop
  - Discharge current

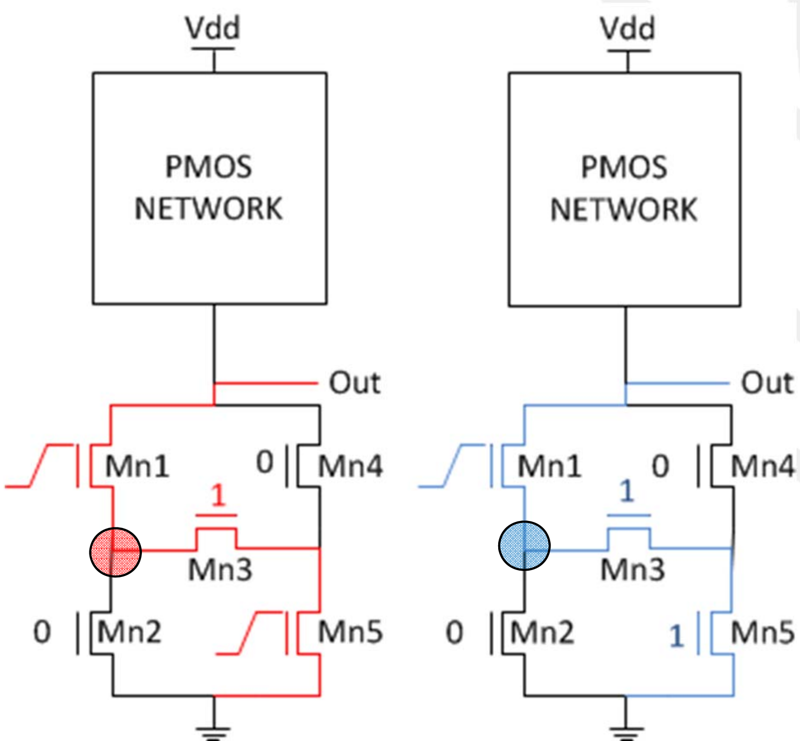
Deriving an analytical delay model

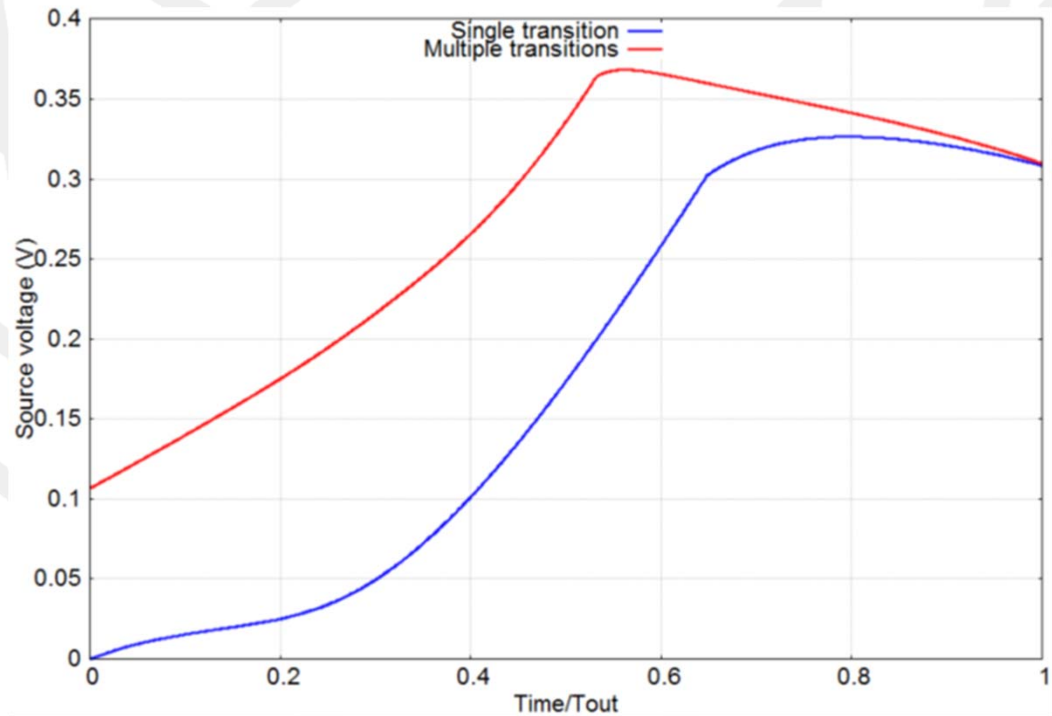
- Required charge to cause the output voltage drop
  - Internal capacitances, output load, short circuit current, I/O coupling capacitance



Deriving an analytical delay model

- Discharge current
  - Switching transistor applied voltages
- Discharge current estimation is different for simultaneous switching





Results

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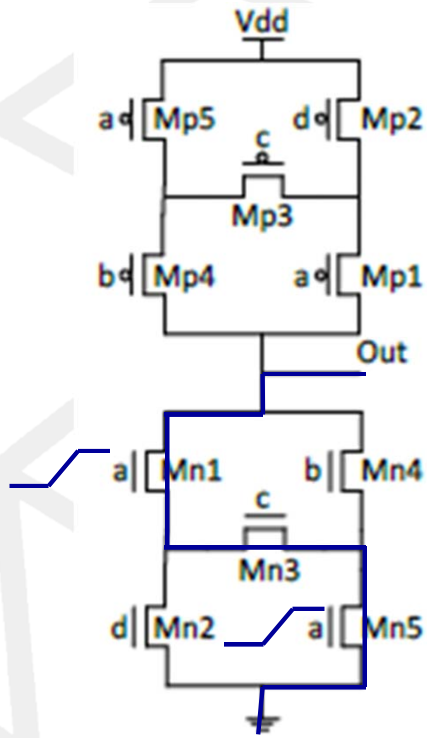
- Industrial 65 nm technology
- Average error ≈3%
- Worst case <10%



Load	*AVG* (%)	*WC* (%)
0.25	2.56	8.70
1	2.52	8.24
4	3.34	7.61
16	4.23	7.50
64	3.04	7.59
256	1.85	2.46

- Similar to reported errors of models focusing on single transition

Work	*AVG* (%)	*WC* (%)
Wang [16]	< 5	NA
Kabbani [15]	4.5	7.5
Lasboygues [14]	3	9
Rossello [13]	3	NA
Daga [12]	NA	<10

Thank you!

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