Slide Set 3

Pass Transistor Logic / Transmission Gates

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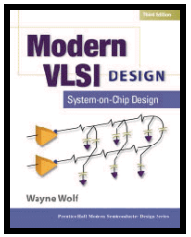
Overview

- Reading
  - Wolf 3.4, 4.7



- Introduction

  In the last lecture, we talked about how simple CMOS gates can be built. In this lecture, we will talk about another way to implement logic functions using transistors: pass-transistor logic (NMOS only) and transmission-gate logic (NMOS and CMOS transistors). For some types of functions, this can lead to much more efficient implementations than using gates.

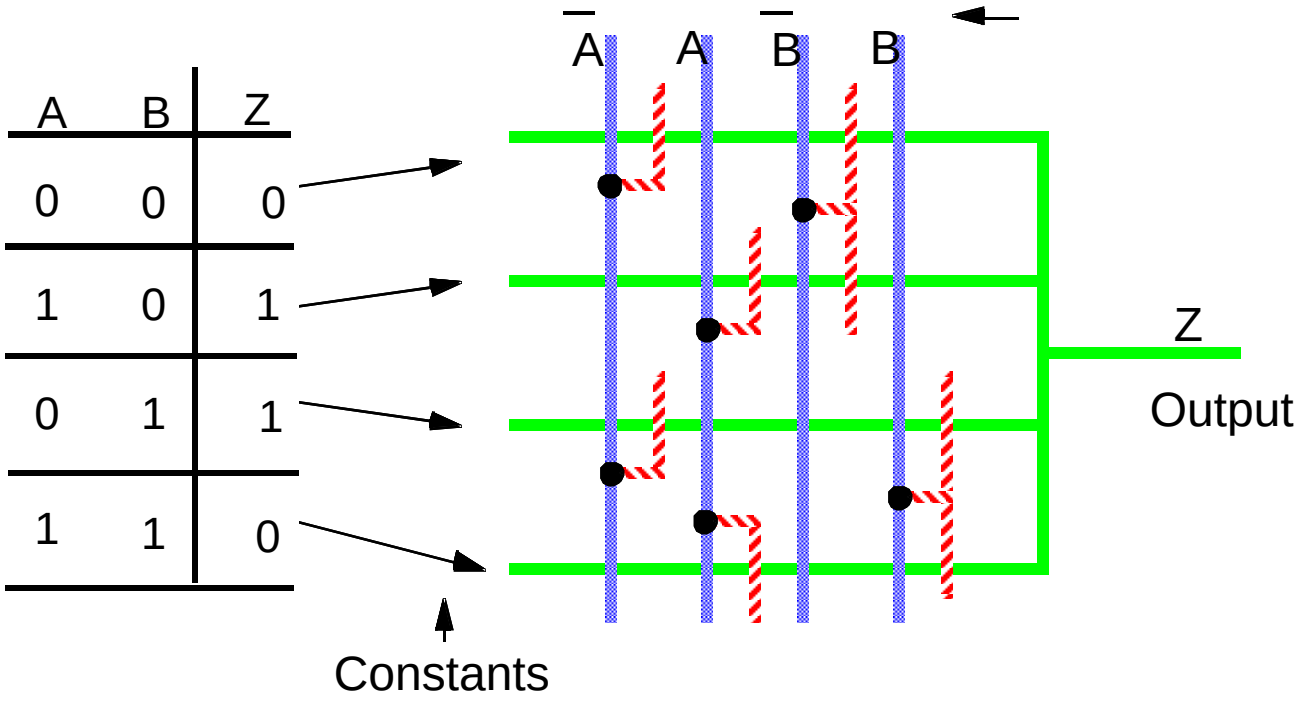
Switch Networks

Board Notes:

- Series Connections, Parallel Connections
- Multiplexer circuit

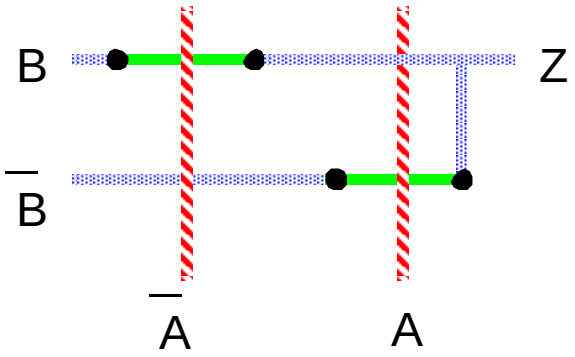
Multiplexer

- A very useful switch network in an input multiplexer. It simply selects one of the inputs to the output. This structure can be used to easily map any logical function into switch logic -- all that needs to be done is present the right constant vector to the inputs of the multiplexer.



Muxes

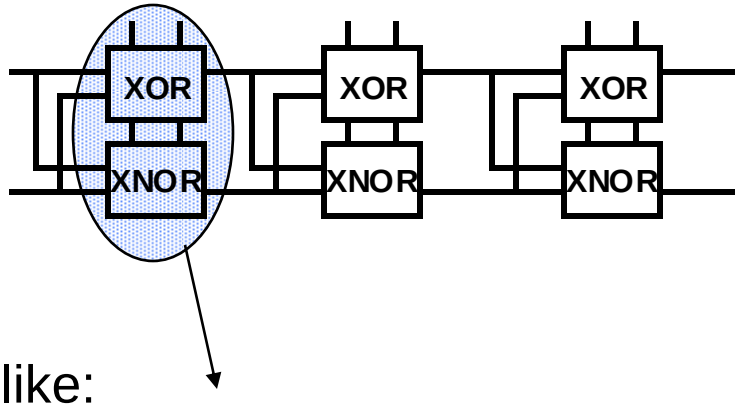
- For some functions you can do better than just using constants and a multiplexer. You can implement an XOR gate in only two transistors (if you assume that both the inputs and their complements are available)
- Notice also the change in floorplan with the inputs staying on poly – makes it more compact



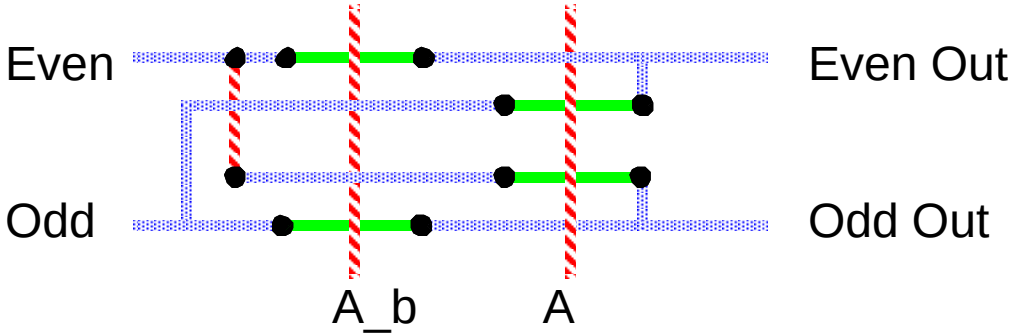
Parity

A more complex switch logic function:

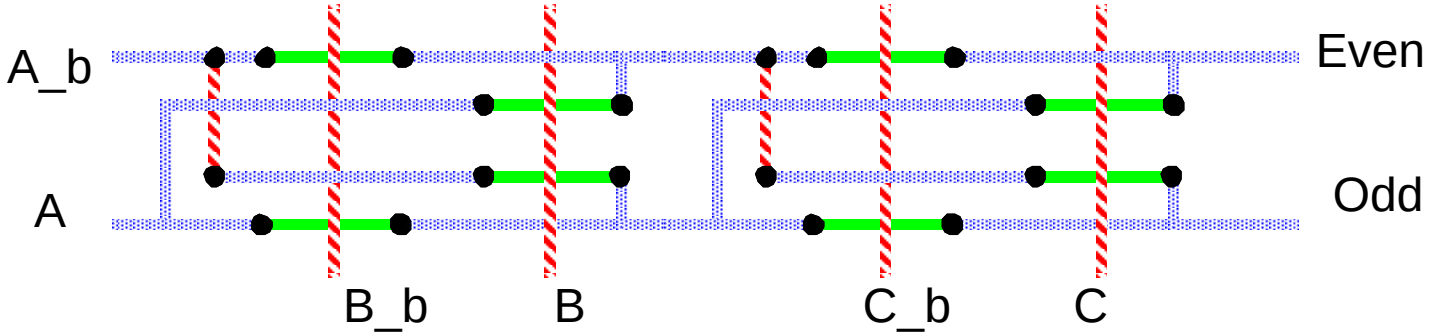
- A **XOR** B **XOR** C **XOR** D …



Each stage looks like:

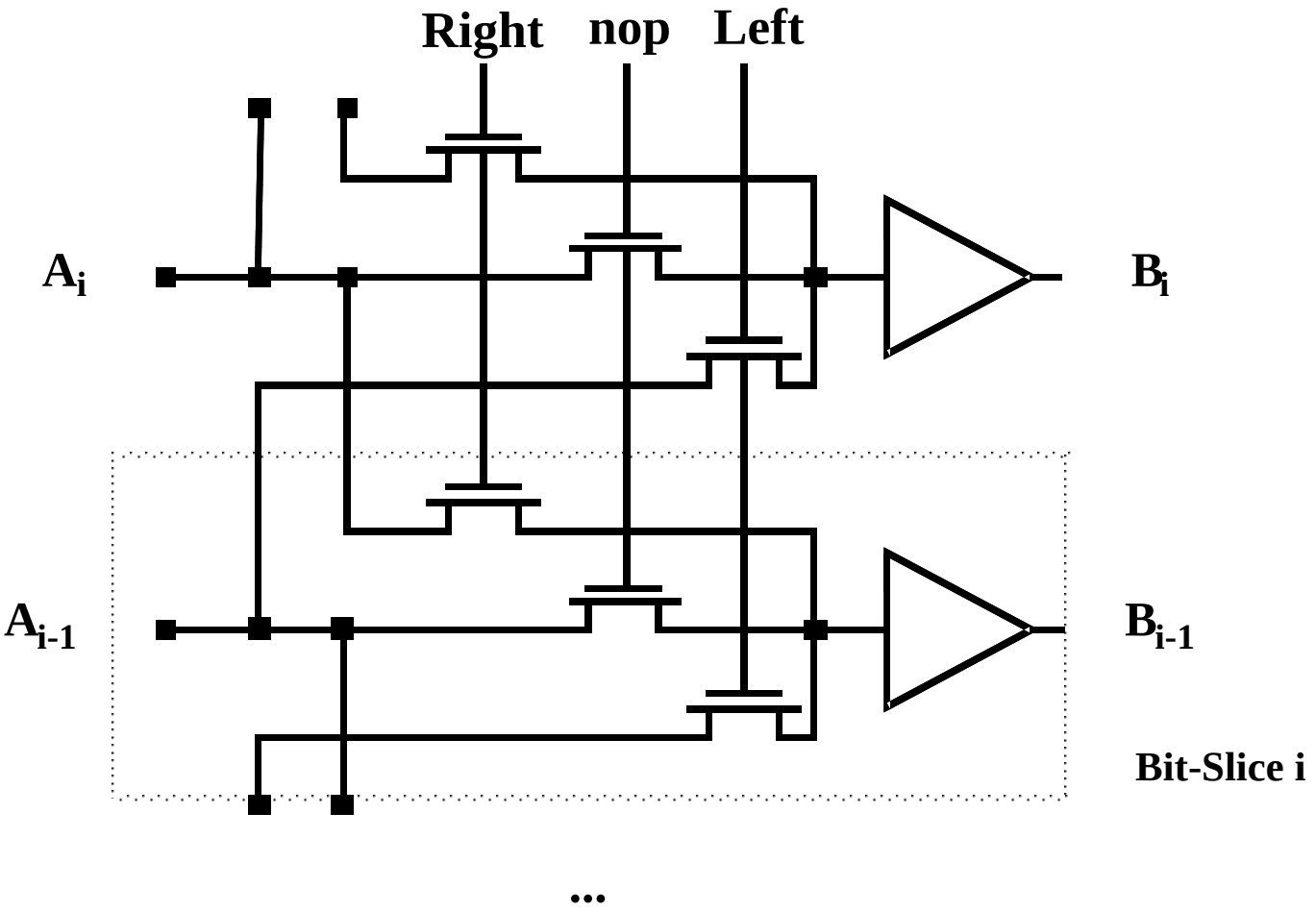


Parity of Three Inputs



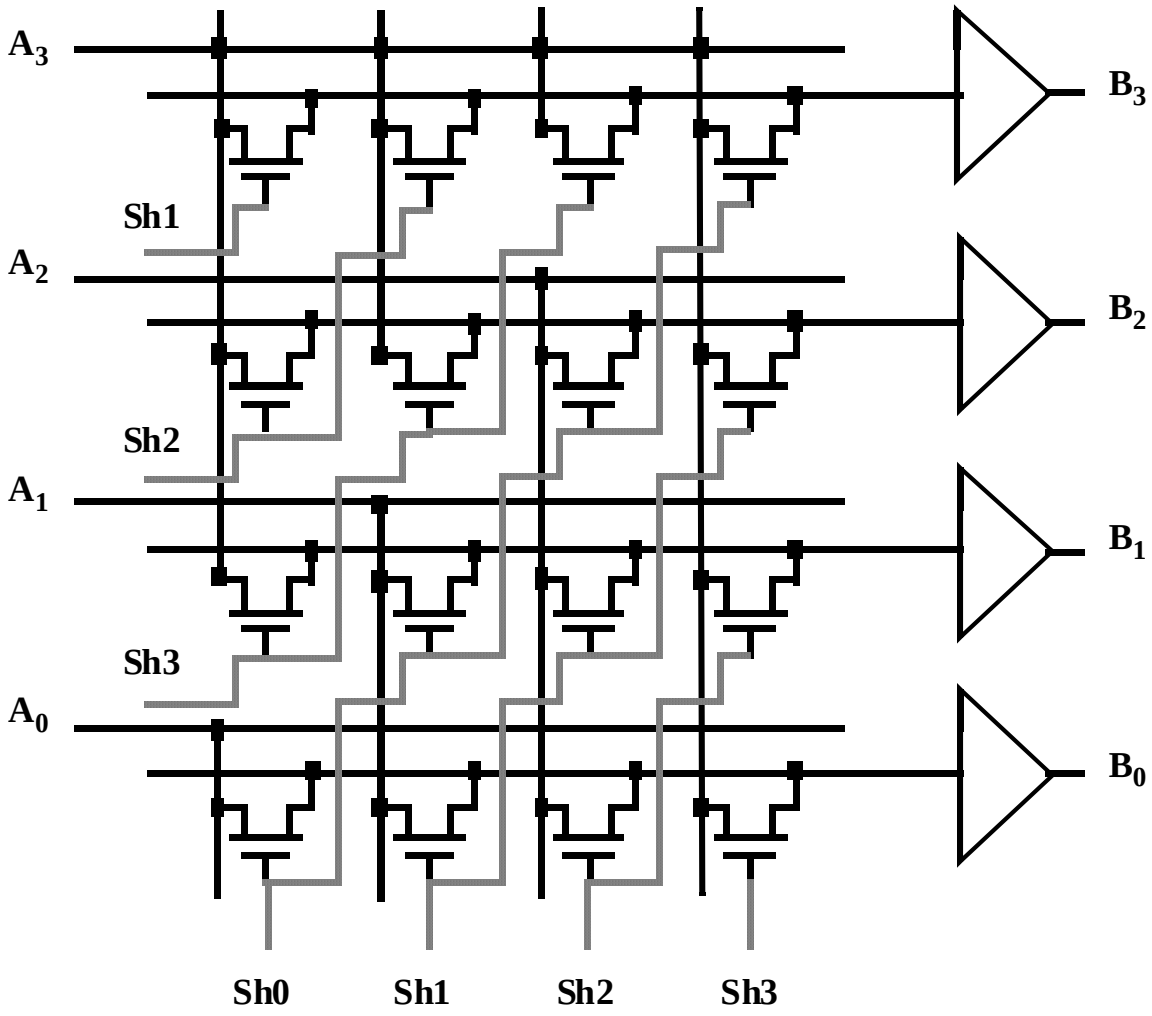
Can cascade them to form a larger structure

Binary Shifter



Source: Jan Rabaey, 1995

Barrel Shifter

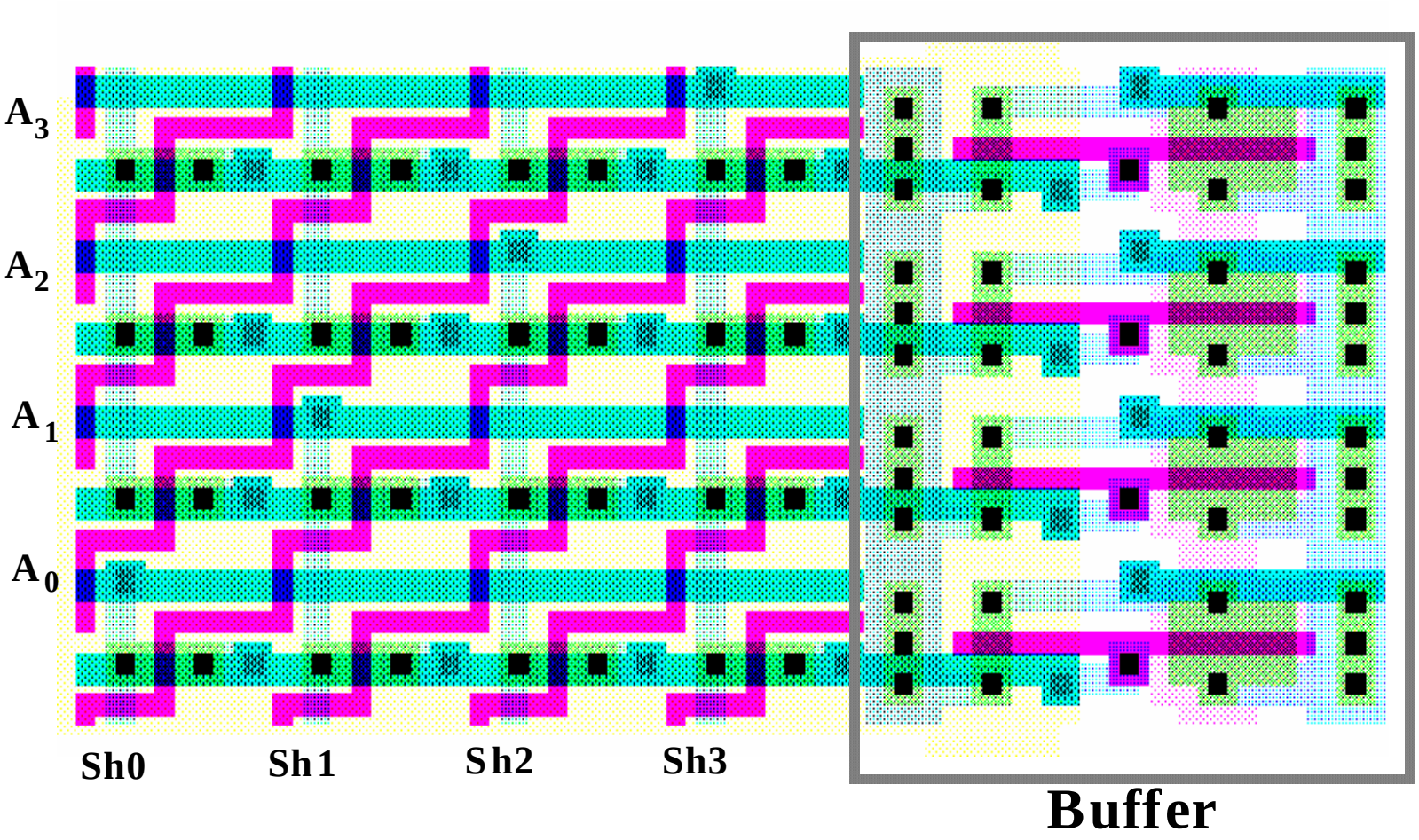


: Data Wire

: Control Wire

Source: Jan Rabaey, 1995

Barrel Shifter Layout

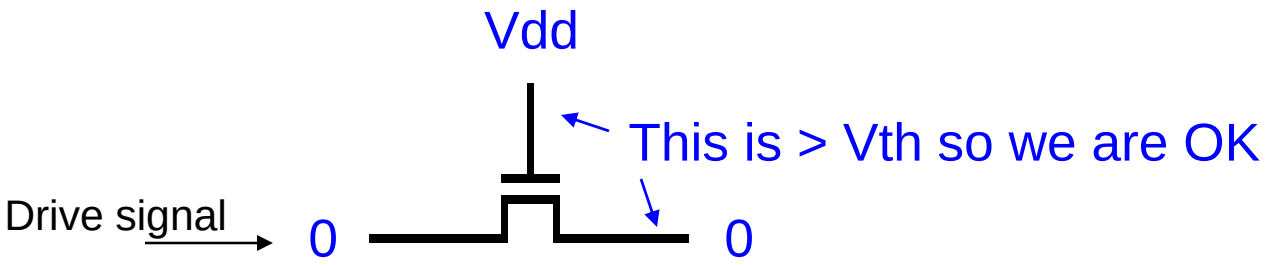


Source: Jan Rabaey, 1995

NMOS Switch Logic

Problem: there must be at least Vth between gate and source for transistor to conduct.

What does this mean?



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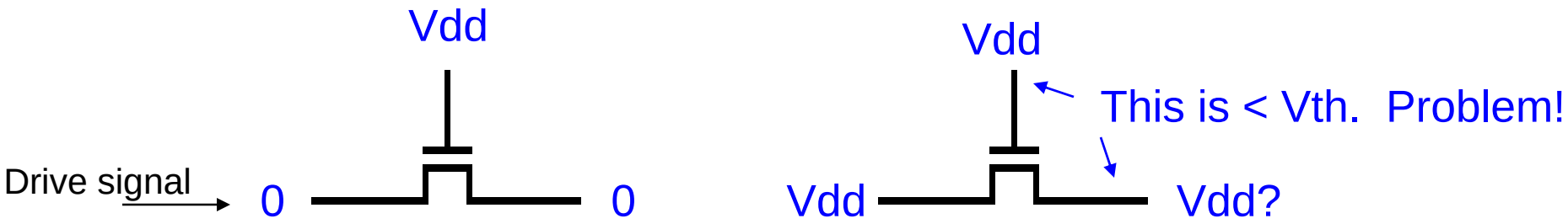

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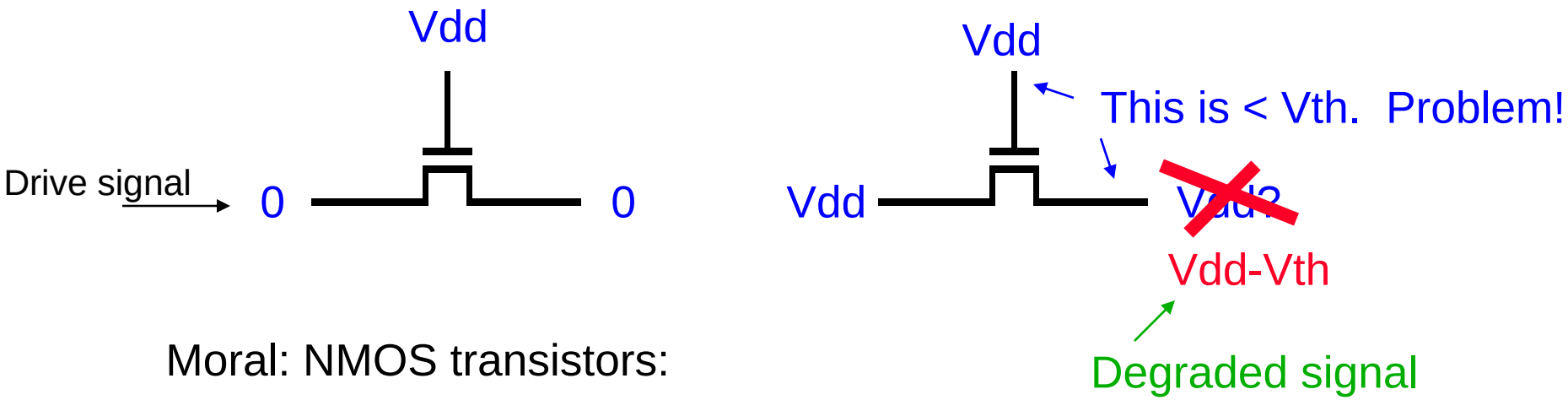
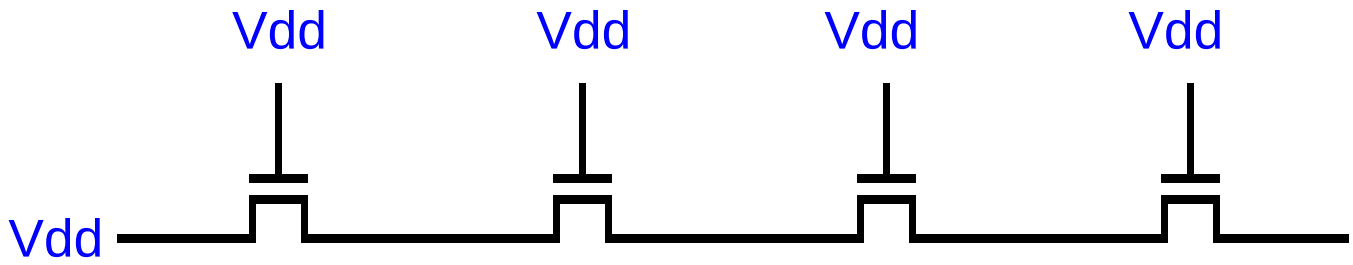


Moral: NMOS transistors:
- pass 0 well
- when passing a 1, there is a Vth voltage drop

NMOS Switch Logic

What about this?



NMOS Switch Logic

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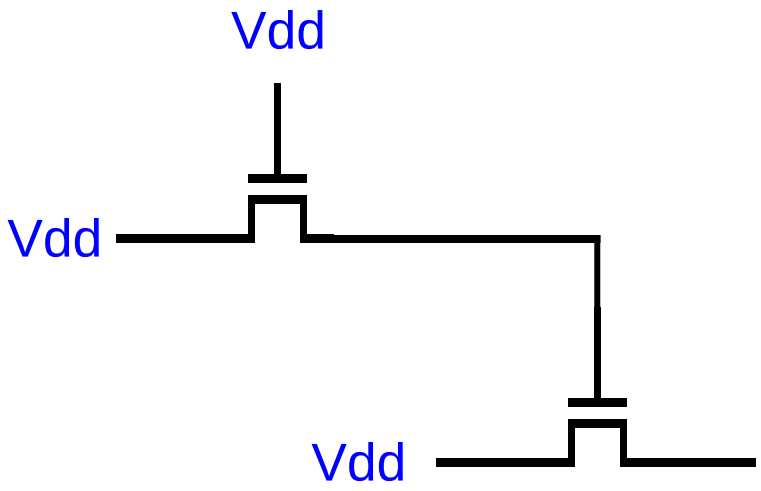
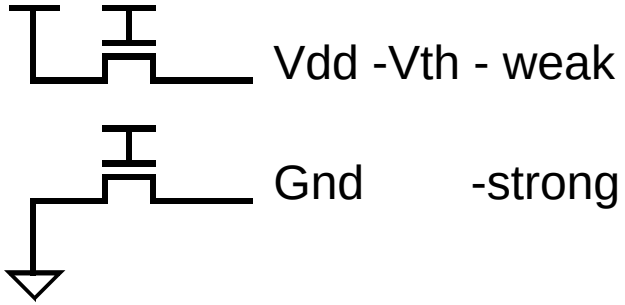


Don’t drive gates with degraded signals

CMOS Transistors

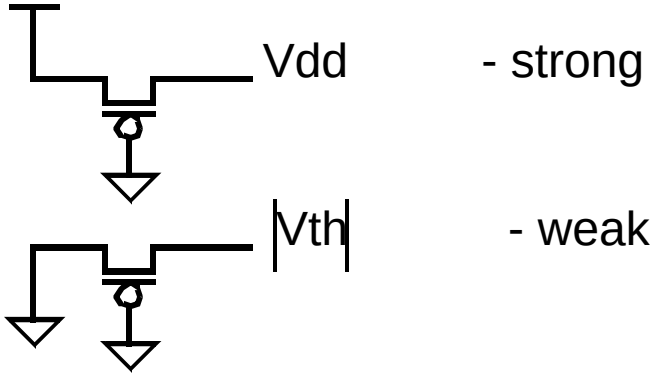
NMOS

- connected when gate is high
- high output is degraded



PMOS

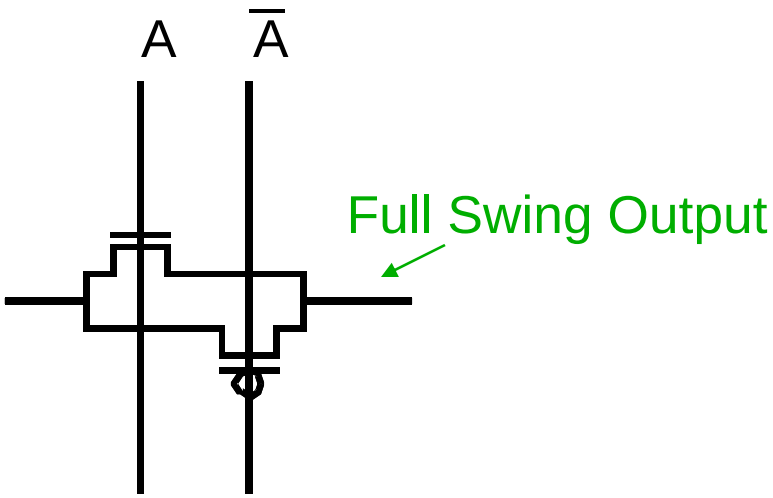
- connected when gate is low
- low output is degraded



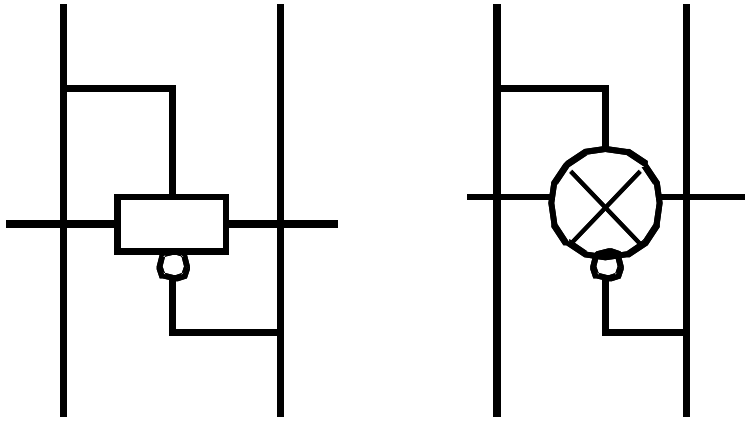
CMOS Switches

By using both NMOS and PMOS neither output is degraded

– But you need the true and complement of the control signal

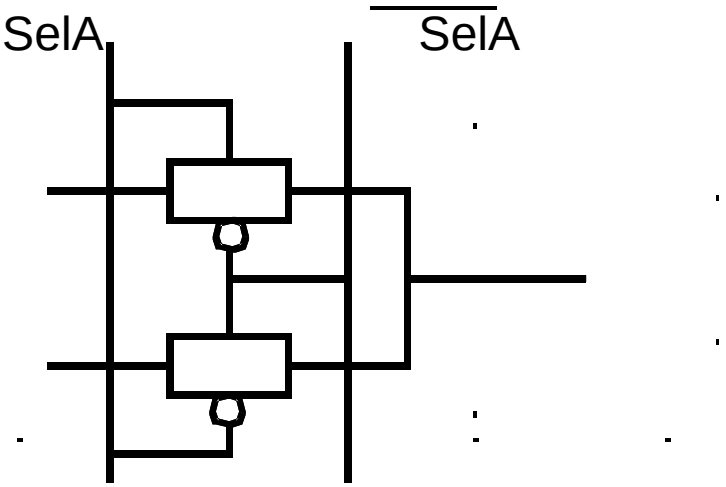


Other symbols used



CMOS Switches

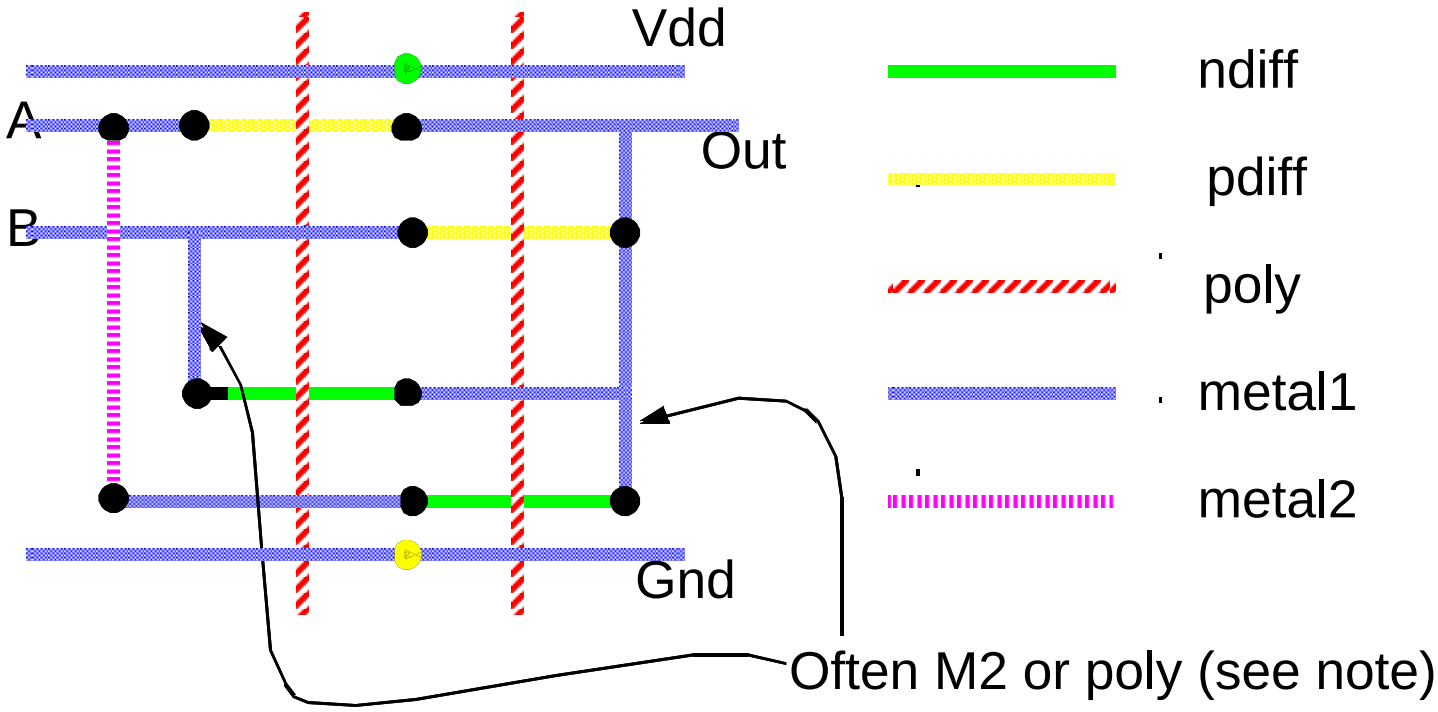
Example: 2-1 Mux:



CMOS switch logic need a large number of control wires

- Each control is needed in true and complement form
- For 2-1 Mux this works out well, but for a 3-1 mux, this means 6 control signals
  - SelA, SelB, SelC and their complements

2-1 Mux Stick Diagram



Note: usually, all metals lines in one direction are on one layer and all metal lines in other direction are on another layer. Here we cheated a bit.

Take Home Exercise

Design an exclusive-or gate in two ways:

1. Using CMOS gates
2. Using transmission gate logic

How many transistors does each use? Which is more efficient?