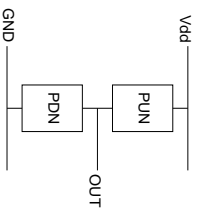


Static CMOS Complementary Gates



- **Static**
After the appropriate propagation delay the output becomes valid and remains valid.¹

- **Complementary**

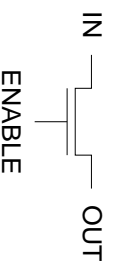
For any set of inputs there will exist either a path to Vdd or a path to GND. Where this condition is not met we have either a high impedance output or a conflict in which the strongest path succeeds. Static CMOS **Non-complementary** gates make use of these possibilities.

¹c.f. Dynamic logic which uses circuit capacitance to store state for a short time.

7001

Pass Transistor Circuits

- Pass Transistor



- Provides very compact circuits.
- Good transmission of logic '0'.
- Poor transmission of logic '1'.
- - slow rise time
- - degradation of logic value

The pass transistor is used in many dynamic CMOS circuits².

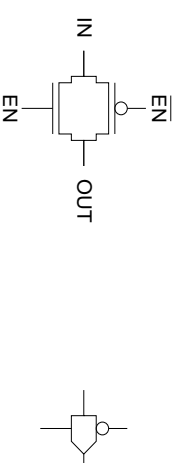
²where pull-up is performed by an alternative method

7002

Pass Transistor Circuits

- Transmission Gate

- For static circuits we would normally use a CMOS transmission gates:

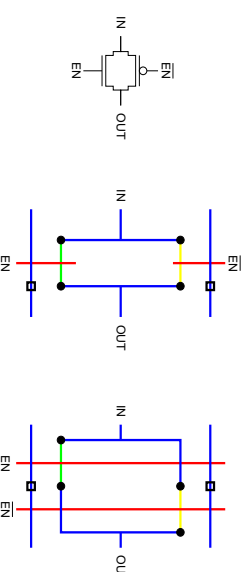


- - balanced n and p pass transistors
- - faster pull-up
- - slower pull-down

7003

Pass Transistor Circuits

- Transmission Gate Layout



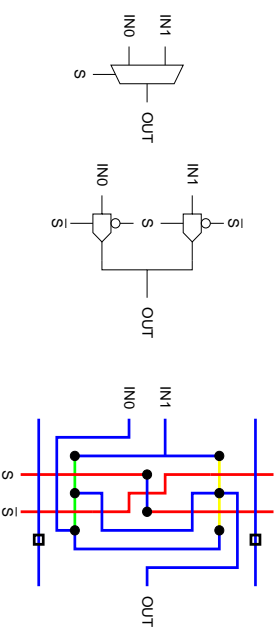
- note that these circuits are not fully complementary³ hence they do not immediately lend themselves to a *line of diffusion* implementation.

³since there are sets of inputs for which the output is neither pulled low nor high

7004

Pass Transistor Circuits

• Transmission Gate Multiplexor

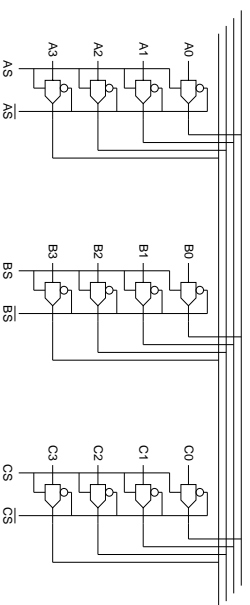


- very few transistors 4 (+2 for inverter)
- difficult layout may offset this advantage
- - prime candidate for 2 level metal

7005

Pass Transistor Circuits

• Bus Wiring

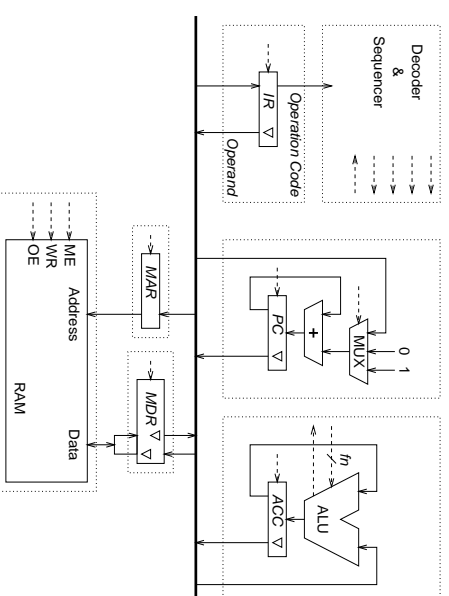


- distributed multiplexing⁴
- only one inverter required per bank of transmission gates
- greatly simplifies global wiring

⁴Internal chip bus should never be allowed to float high impedance

7006

Bus Distributed Multiplexing

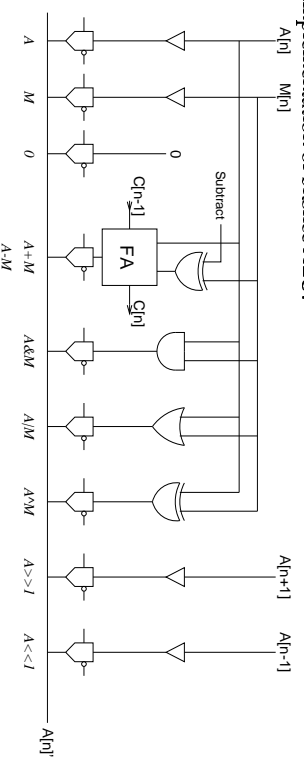


Ideal for signals with many drivers from different modules.

7007

Bus Distributed Multiplexing

Implementation of bitslice ALU:⁵

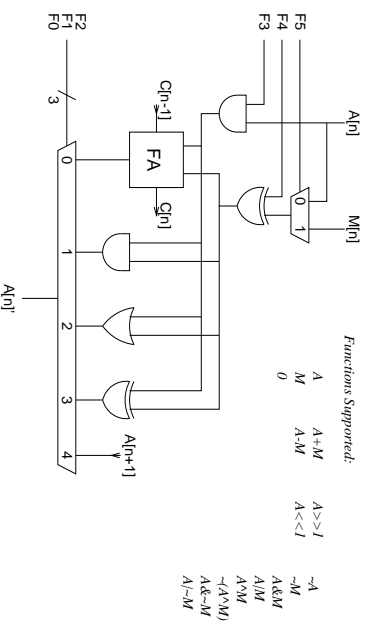


- Separate circuit for each function
- Connected via distributed multiplexor

⁵Note that transmission gates have no drive capability in themselves. Here a good drive is ensured by providing buffers.

7008

Bus Distributed Multiplexing

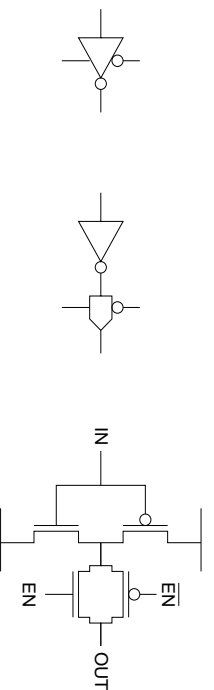


- Single optimized ALU module
- Multiplexing is not distributed
- Multiplexer implementation may use transmission gates

7009

Pass Transistor Circuits

- Tristate Inverter

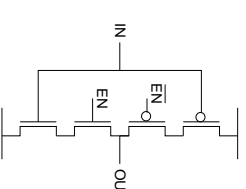


- Any gate may have a tri-state output by combining it with a transmission gate.

7010

Pass Transistor Circuits

- Tristate Inverter

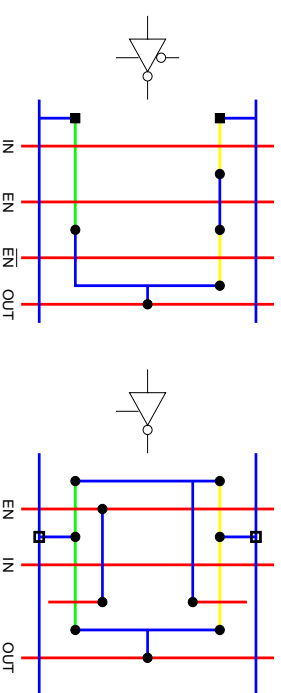


- Alternatively the transmission gate may be incorporated into the gate.
 - - one connection is removed - easier to layout
 - - also easier to simulate!

7011

Pass Transistor Circuits

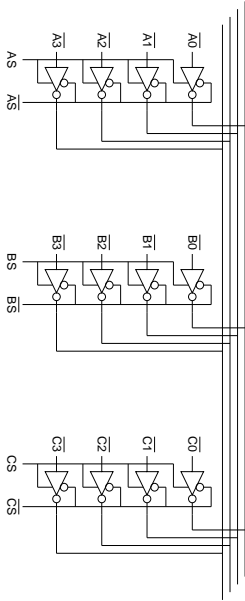
- Tristate Inverter Layout



7012

Pass Transistor Circuits

- Tristate Inverter Bus Driver



- a tristate inverting buffer is often used to drive high capacitance bus signals
- transistors may be sized as required