

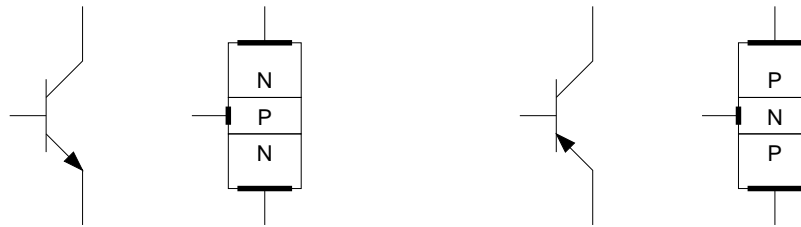
Overview of Technologies

Components for Logic

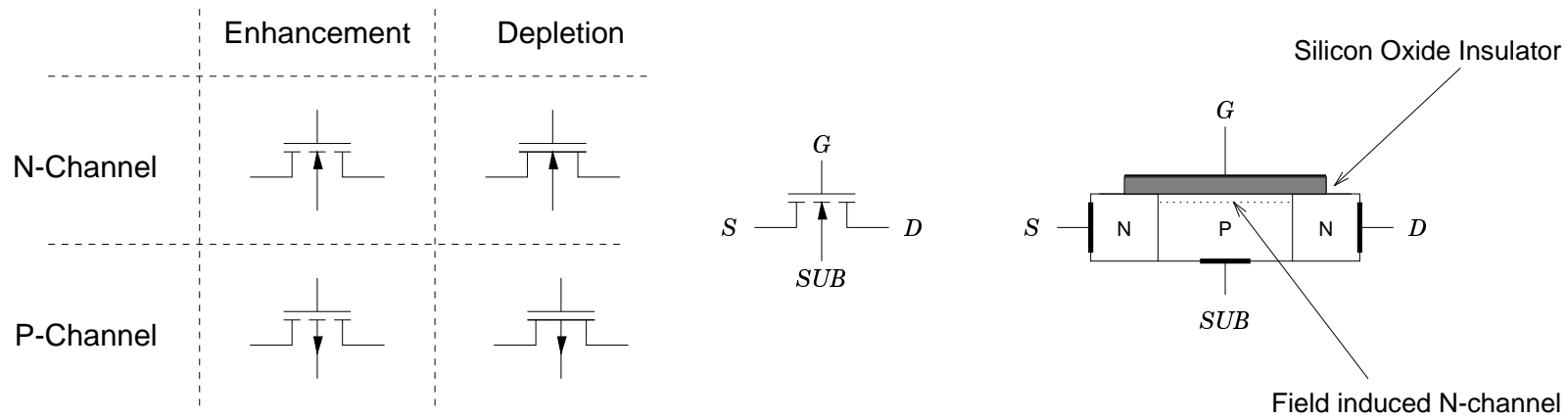
Diode



Bipolar Transistors

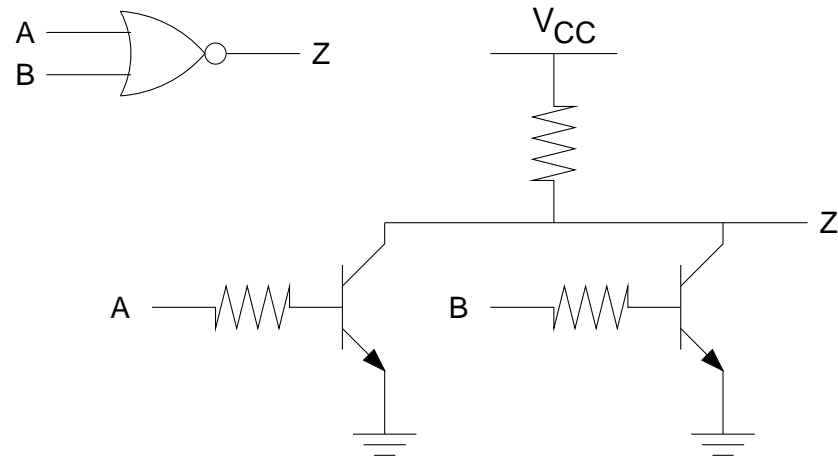
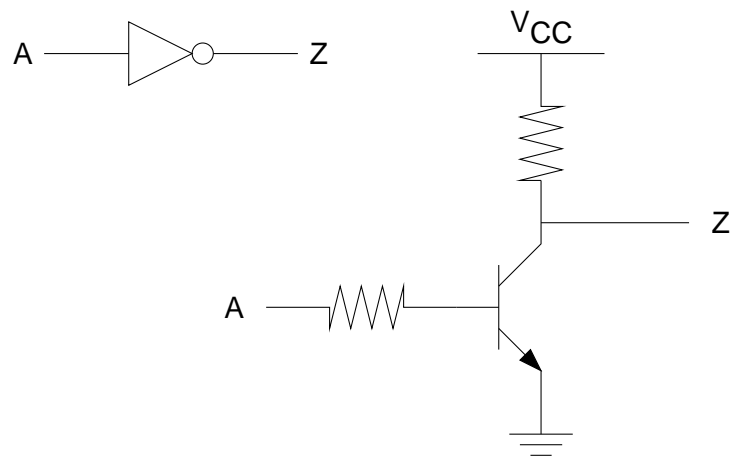


MOS Transistors



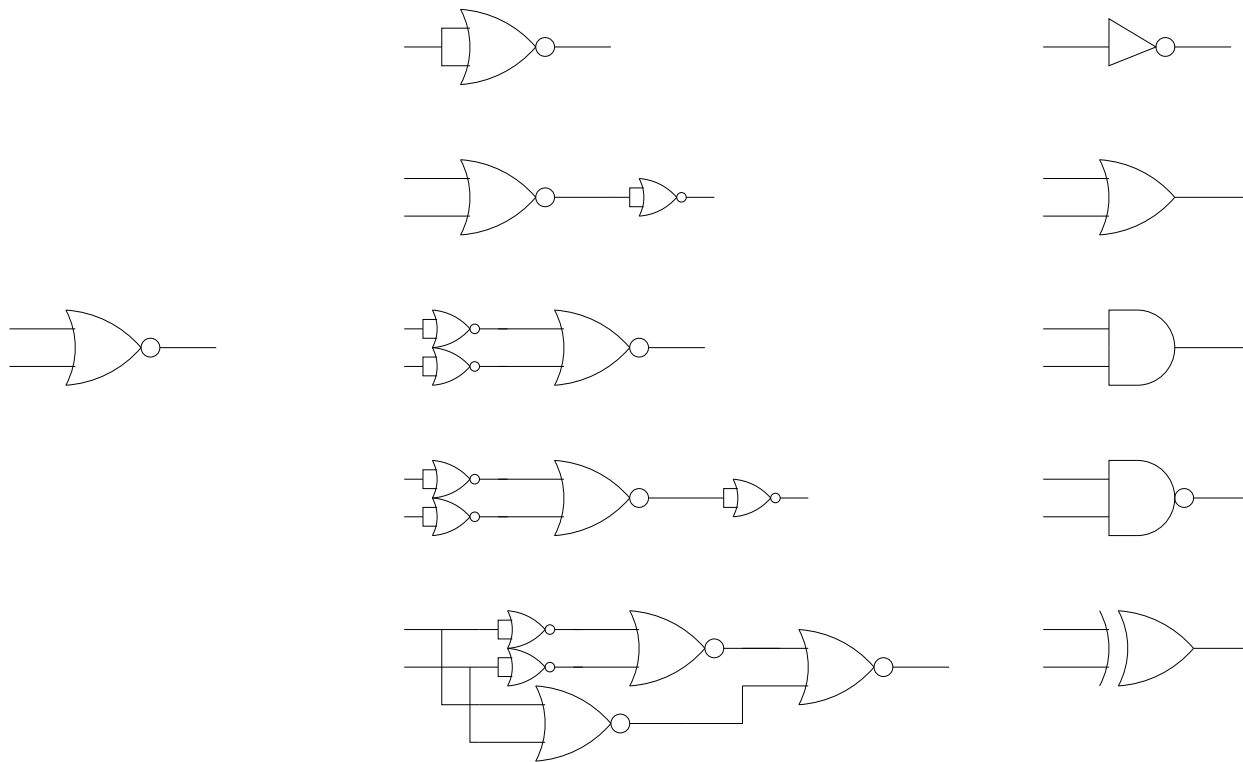
Overview of Technologies

RTL Inverter and NOR gate



Overview of Technologies

All functions can be realized with a single NOR base gate.¹

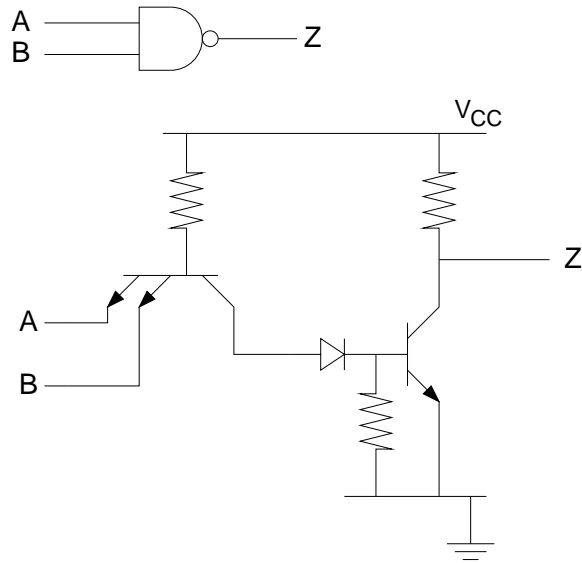


¹NAND gates could be used instead.

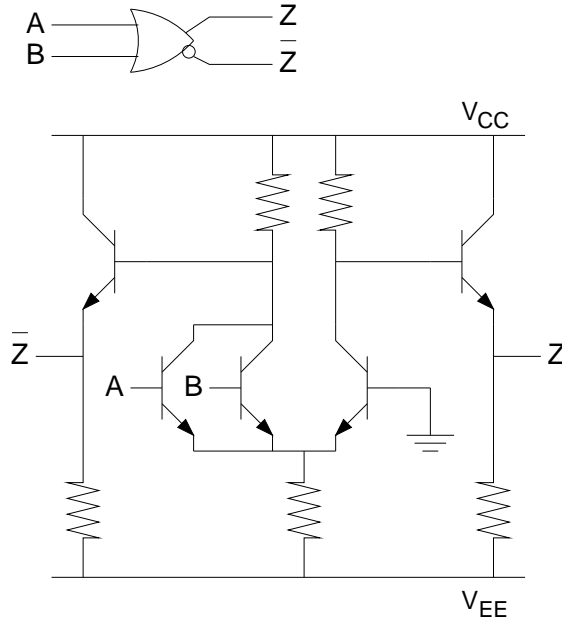
Overview of Technologies

Other Bipolar Technologies

TTL NAND Gate



ECL OR/NOR Gate

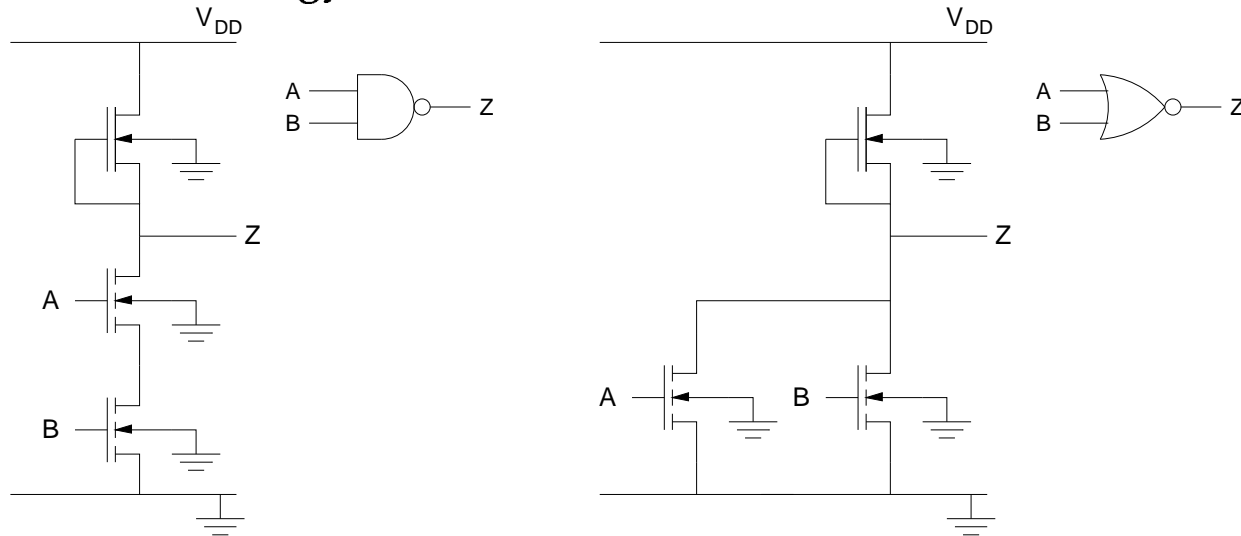


- **TTL** gives faster switching than RTL at the expense of greater complexity². The characteristic multi-emitter transistor reduces the overall component count.
- **ECL** is a very high speed, high power, non-saturating technology.

²Most TTL families are more complex than the basic version shown here

Overview of Technologies

NMOS - a VLSI technology.

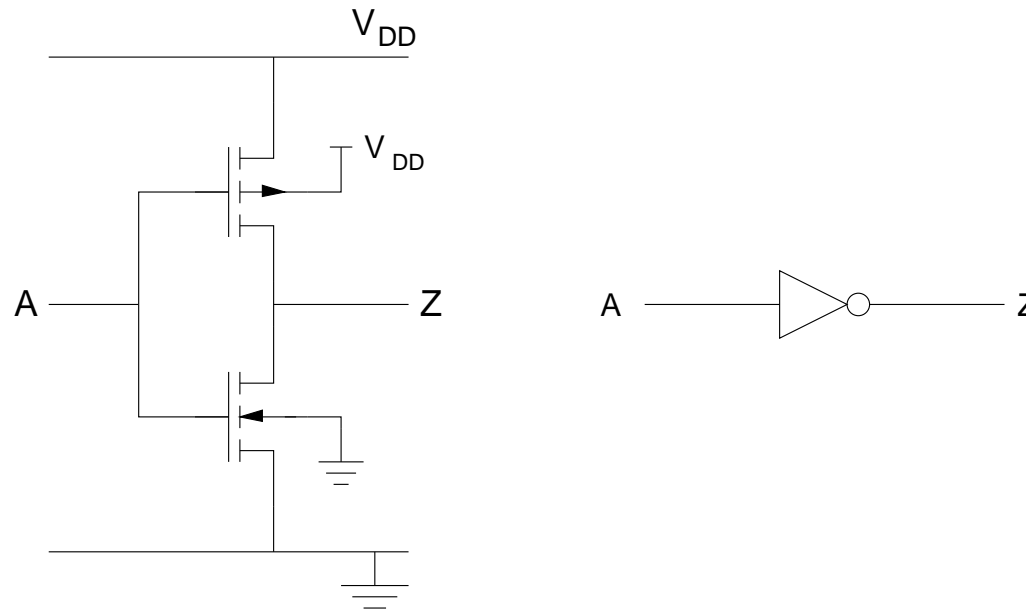


- Circuit function determined by series/parallel combination of devices.
- Depletion transistor acts as non-linear load resistor.
Resistance increases as the enhancement device turns on, thus reducing power consumption.
- The low output voltage is determined by the size ratio of the devices.

Overview of Technologies

CMOS logic

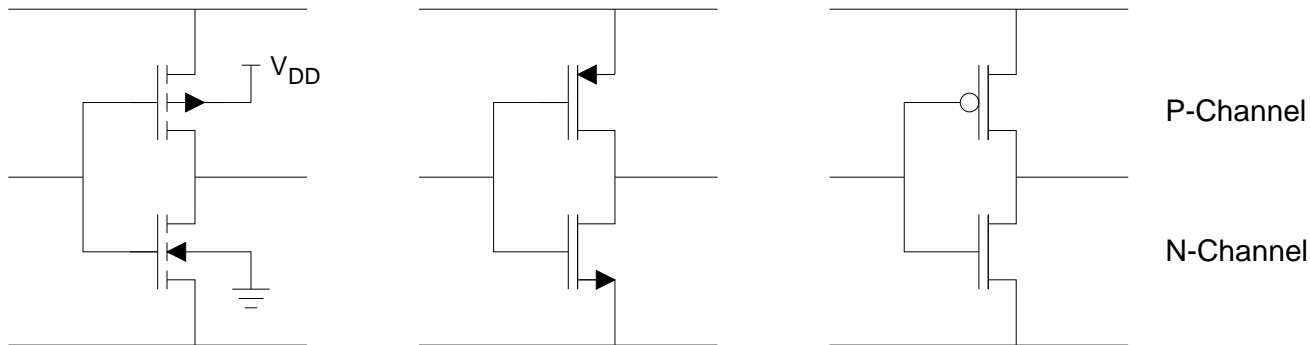
CMOS - *state of the art* VLSI.



- An active PMOS device complements the NMOS device giving:
 - rail to rail output swing.
 - negligible static power consumption.

Digital CMOS Circuits

Alternative representations for CMOS transistors

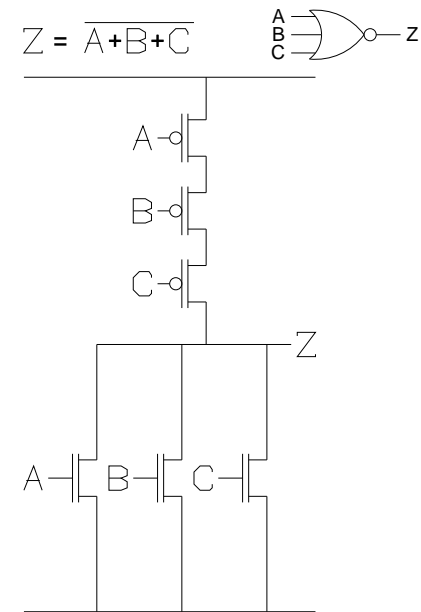
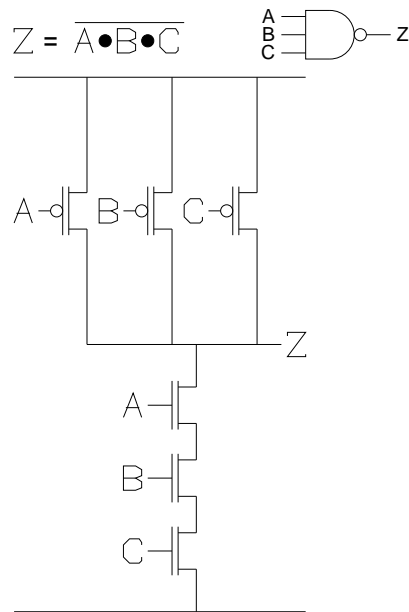
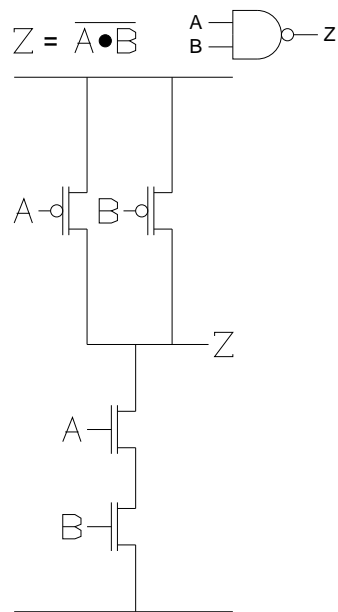


Various shorthands are used for simplifying CMOS circuit diagrams.

- In general substrate connections are not drawn where they connect to V_{DD} (PMOS) and Gnd (NMOS).
- All CMOS devices are enhancement mode.
- Transistors act as simple digitally controlled switches.

Digital CMOS Circuits

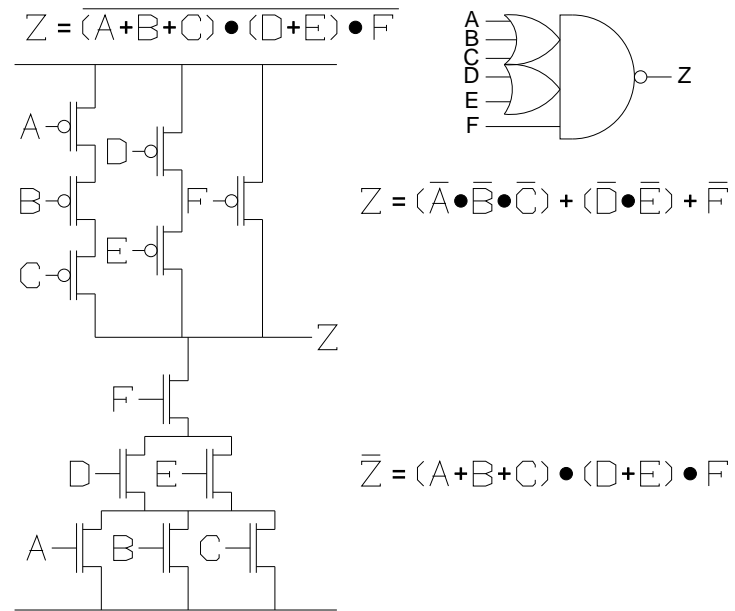
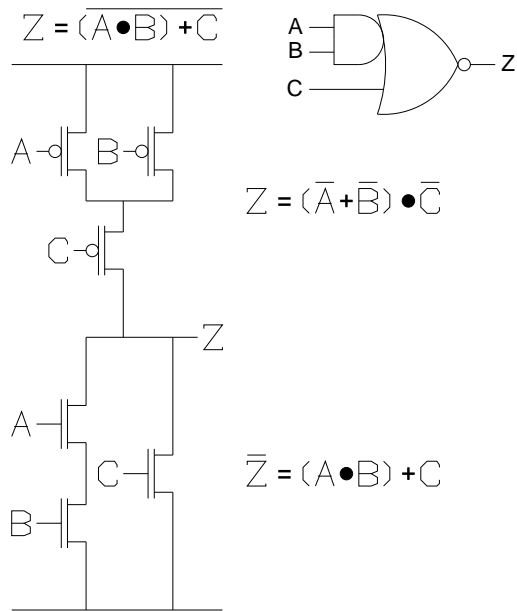
Static CMOS complementary gates



- For any set of inputs there will exist either a path to Vdd or a path to Gnd.

Digital CMOS Circuits

Compound Gates



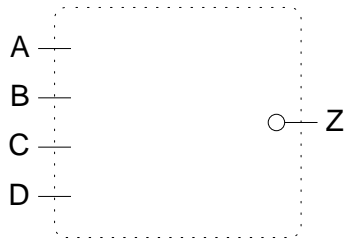
- All compound gates are inverting.
- Realisable functions are arbitrary AND/OR expressions with inverted output.

Digital CMOS Circuits

Compound Gate Example

$$Z = \overline{(A \bullet B) + (C \bullet D)}$$

Symbol



Pull Up Network

$$Z = f(\bar{A}, \bar{B}, \bar{C}, \bar{D})$$

$$Z = \dots\dots\dots$$

Pull Down Network

$$\bar{Z} = f(A, B, C, D)$$

$$\bar{Z} = (A \bullet B) + (C \bullet D)$$

————— V_{DD}

————— Z

————— GND