Wentworth Institute of Technology
Department of Electrical Engineering and Technology

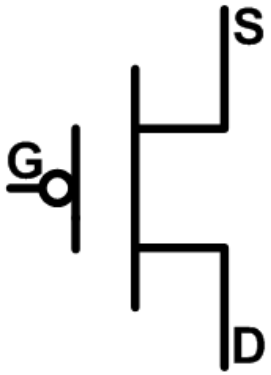
Review of Digital Circuits

(Chapter 2)

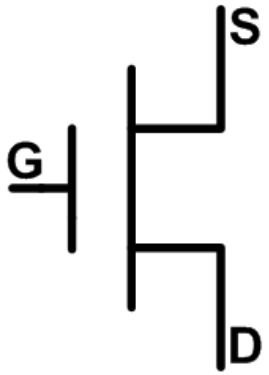
Introduction

- Digital circuits are the essential parts of a microcontroller.
- Although the end users never see them, all operations are performed using digital circuits.
- We begin the review the basics of digital circuits with MOSFET transistors.
- Step by step, we will look at more complex circuitry.

Transistor as a Switch



PMOS



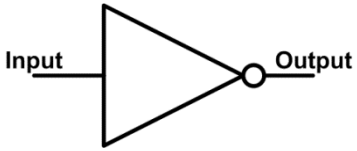
NMOS

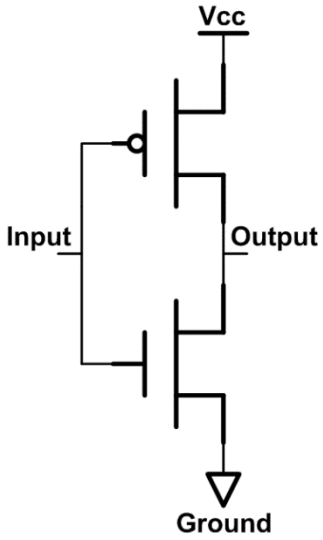
NMOS and PMOS MOSFET transistors can be used as a switch.

Logic 0 corresponds to 0 V.
Logic 1 corresponds to V_{CC}.

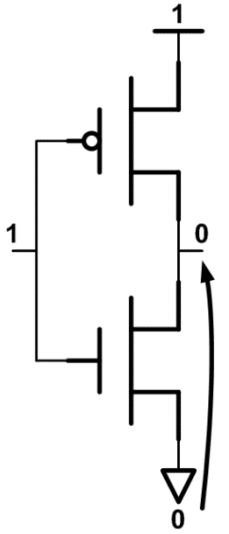
Logic Gates from Transistors: NOT Gate

NOT gate

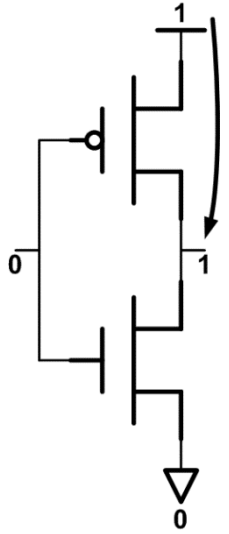




The circuitry



Input is 1

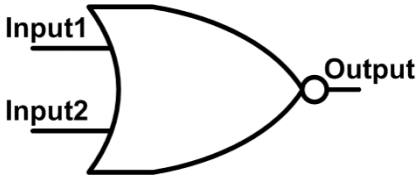


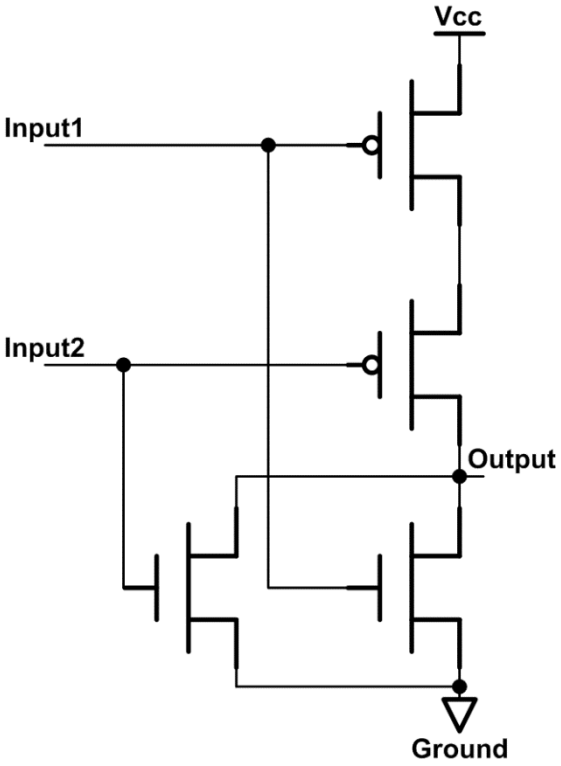
Input is 0

The NOT gate is a simple logic level inverter.

Logic Gates from Transistors: NOR/OR Gates

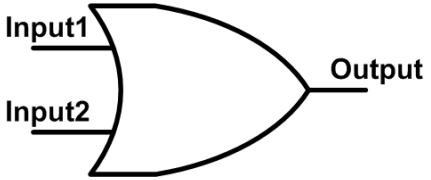
NOR gate

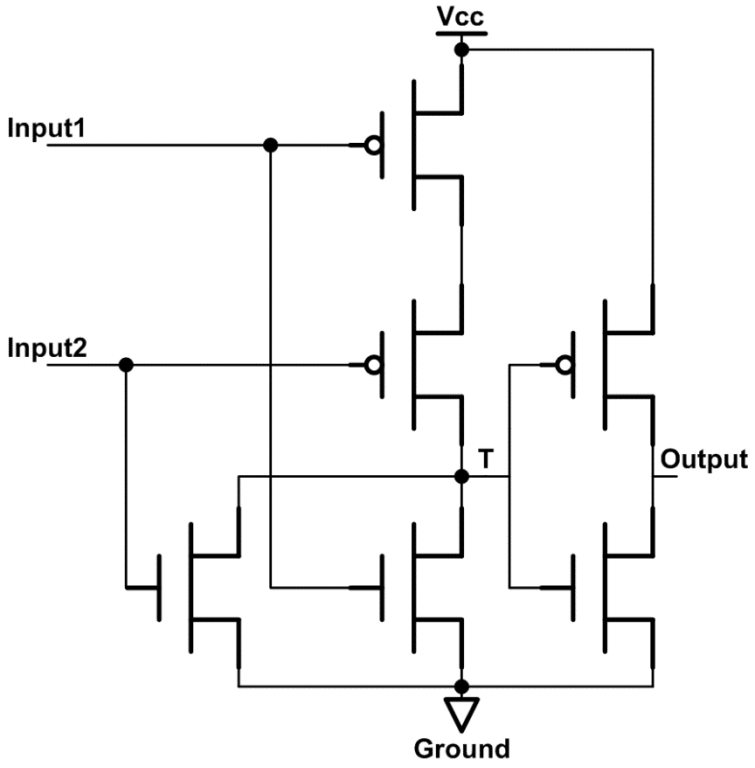




The circuitry

OR gate

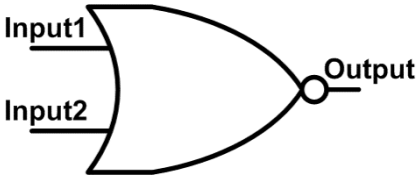




The circuitry

Logic Gates from Transistors: NOR/OR Gates

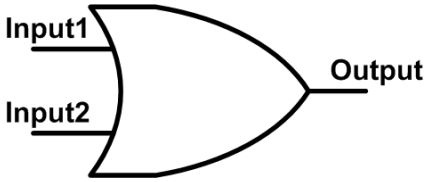
NOR gate



The truth table

Input1	Input2	Output
0	0	1
0	1	0
1	0	0
1	1	0

OR gate

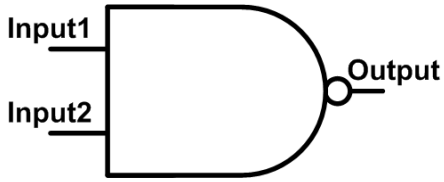


The truth table

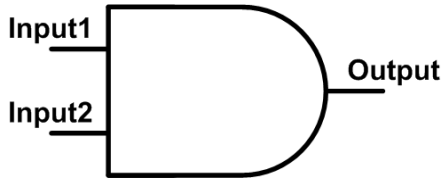
Input1	Input2	Output
0	0	0
0	1	1
1	0	1
1	1	1

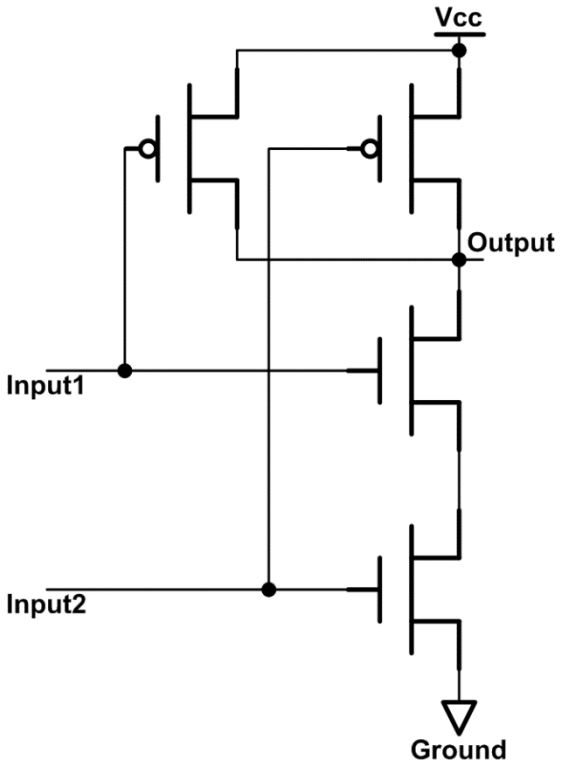
Logic Gates from Transistors: NAND/AND Gates

NAND gate

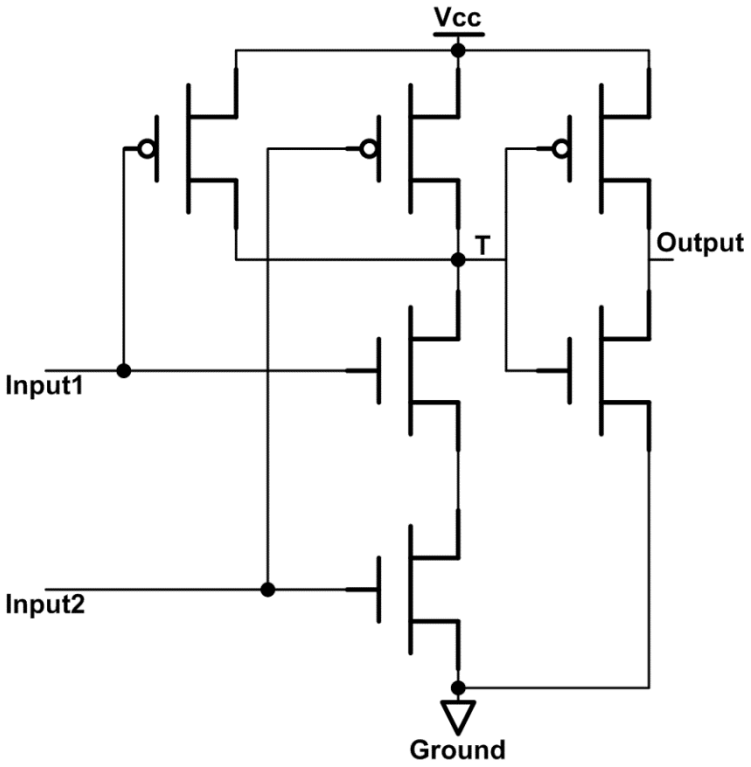


AND gate





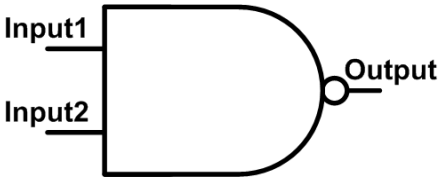
The circuitry



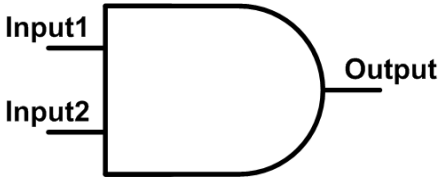
The circuitry

Logic Gates from Transistors: NAND/AND Gates

NAND gate



AND gate



The truth table

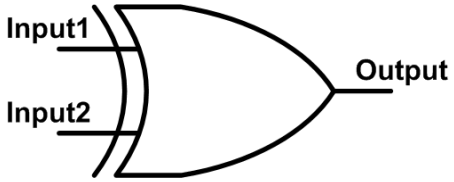
Input1	Input2	Output
0	0	1
0	1	1
1	0	1
1	1	0

The truth table

Input1	Input2	Output
0	0	0
0	1	0
1	0	0
1	1	1

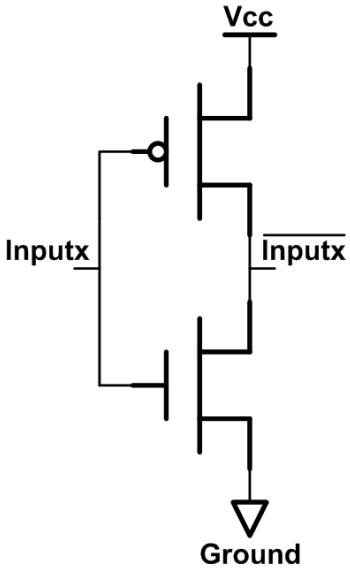
Logic Gates from Transistors

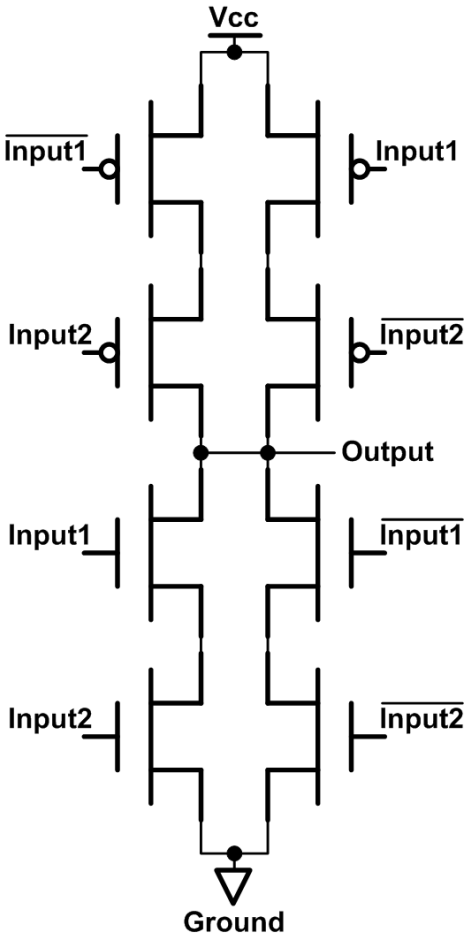
XOR gate



The truth table

Input1	Input2	Output
0	0	0
0	1	1
1	0	1
1	1	0

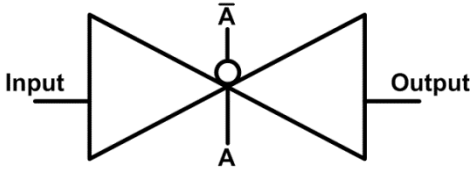


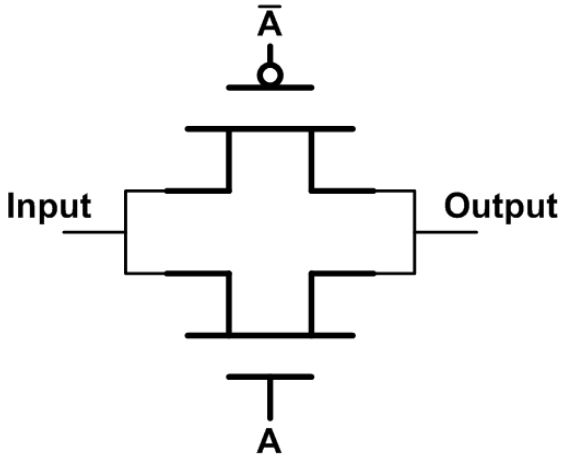


The circuitry

Logic Gates from Transistors: Transmission gate

Transmission gate

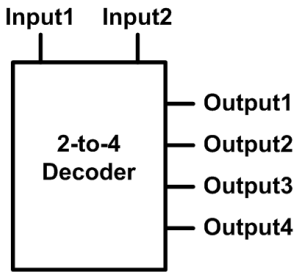




The circuitry

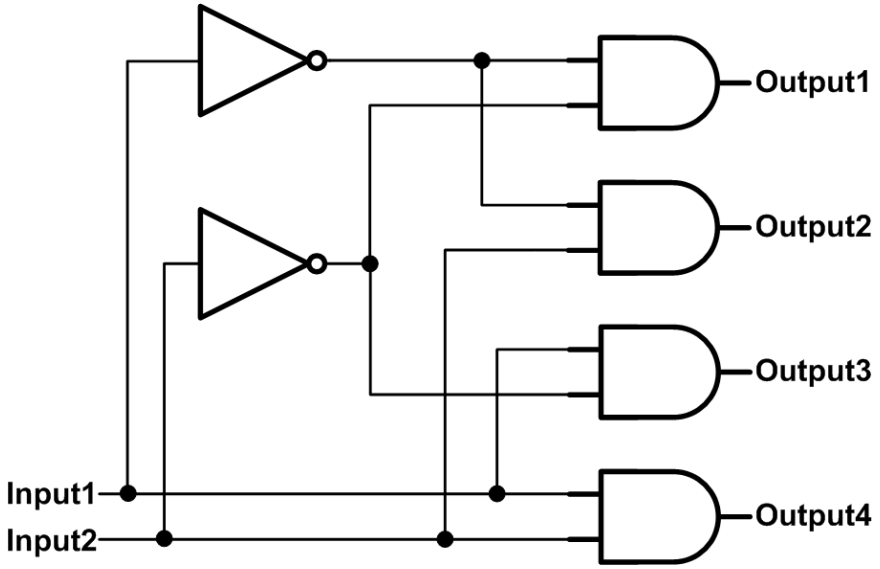
Combinational Circuits from Gates: Decoder

Two to four decoder



The truth table

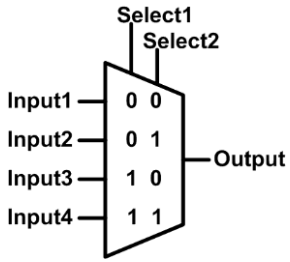
Input1	Input2	Output1	Output2	Output3	Output4
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1



The circuitry

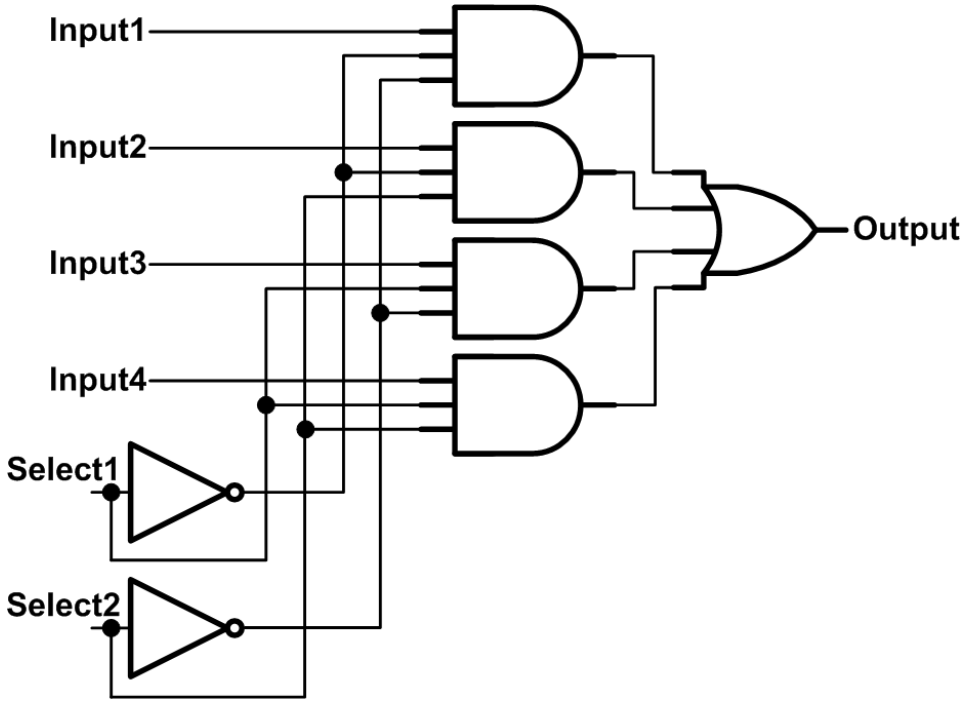
Combinational Circuits from Gates: Multiplexer

Multiplexer



The truth table

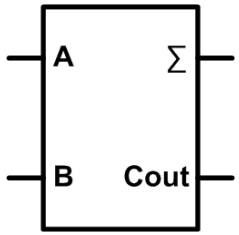
Select1	Select2	Output
0	0	Input1
0	1	Input2
1	0	Input3
1	1	Input4



The circuitry

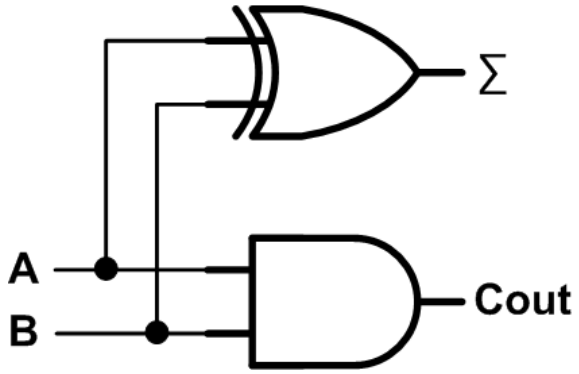
Combinational Circuits from Gates: Half Adder

Half Adder



The truth table

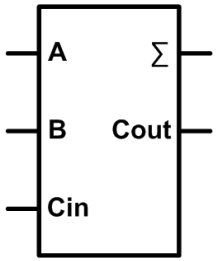
A	B	∑	Cout
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



The circuitry

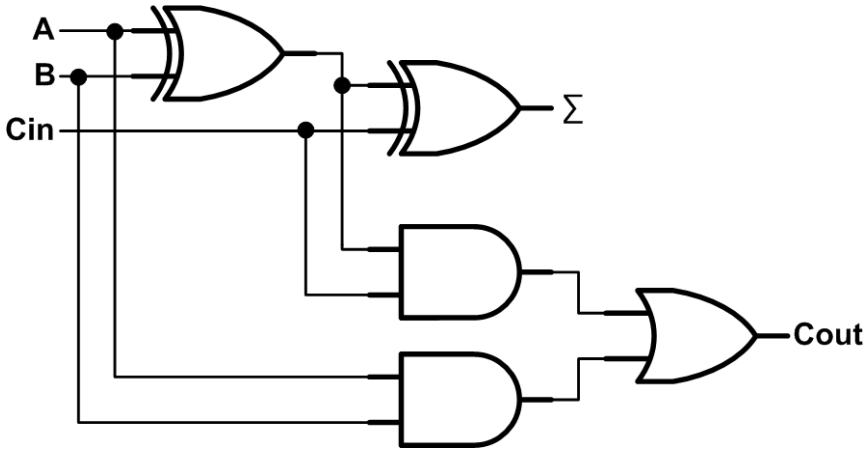
Combinational Circuits from Gates: Full Adder

Full Adder



The truth table

A	B	Cin	∑	Cout
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1



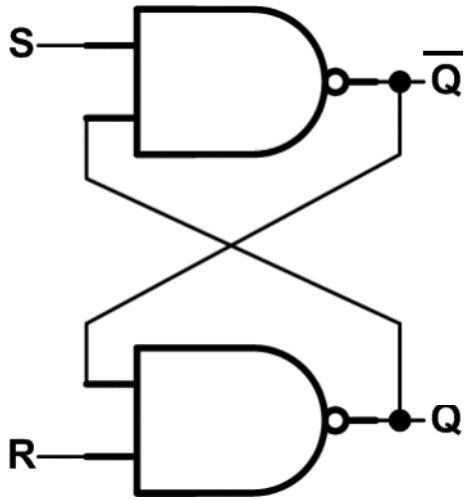
The circuitry

Sequential Circuits from Gates: S-R Latch

S-R Latch

The truth table

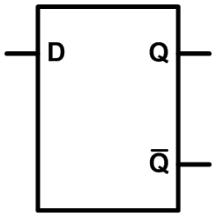
S	R	Q	$\overline{Q}$
0	0	**Not Allowed**	
0	1	0	1
1	0	1	0
1	1	Q	$\overline{Q}$



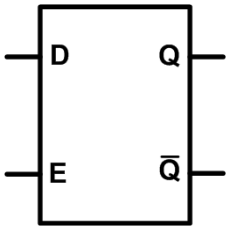
The circuitry

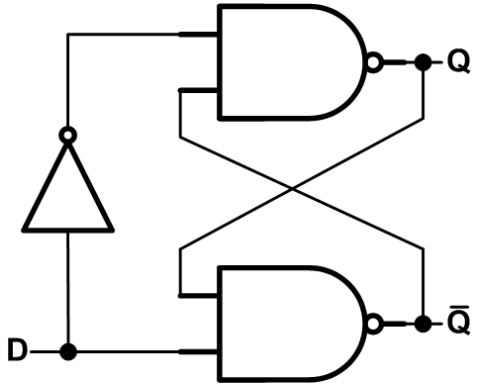
Sequential Circuits from Gates: D Latch

D Latch

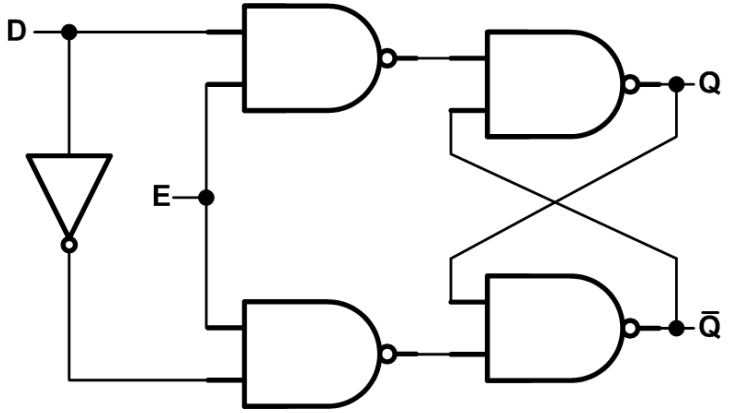


Gated D Latch





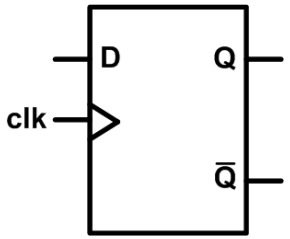
The circuitry

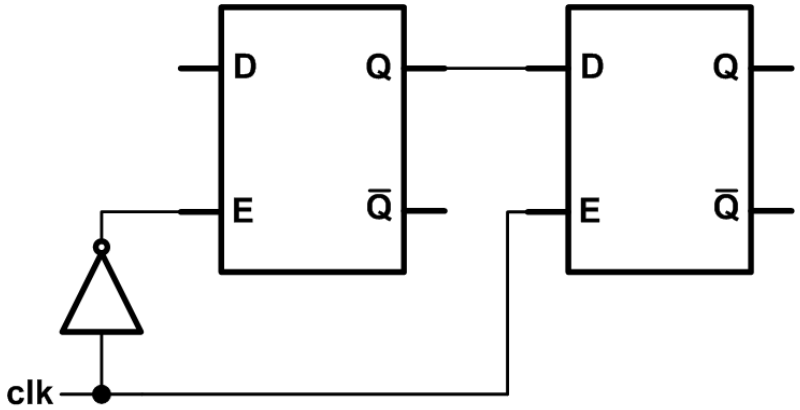


The circuitry

Sequential Circuits from Gates: Master-slave flip flop

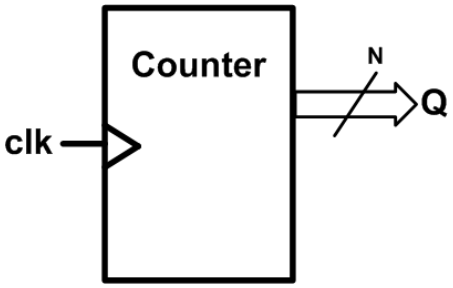
Master-slave flip flop

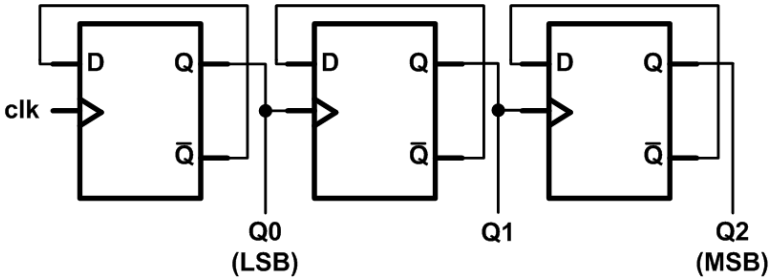




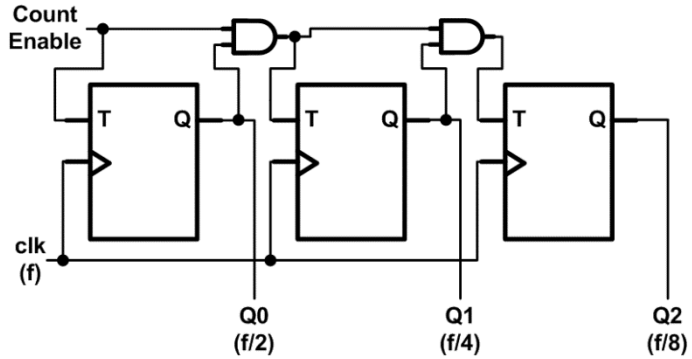
Sequential Circuits from Gates: Counter

Counter





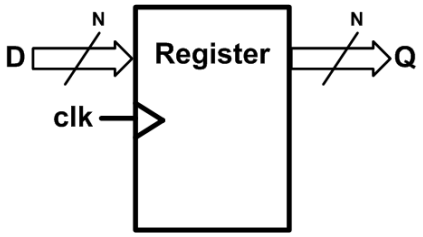
Three bit ripple counter

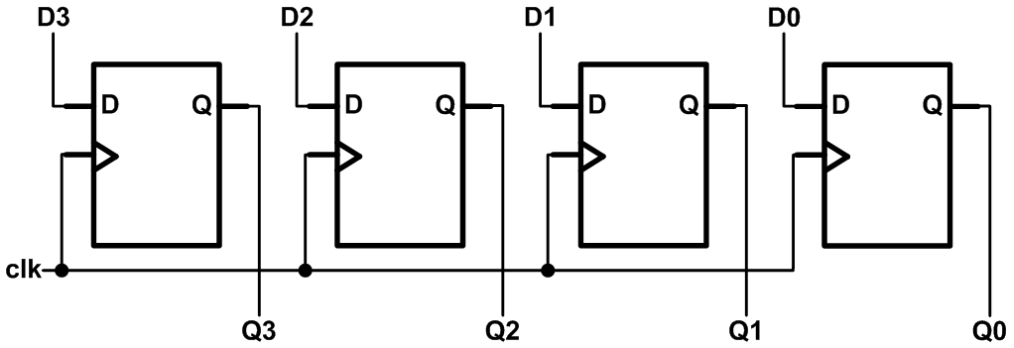


Three bit synchronous counter

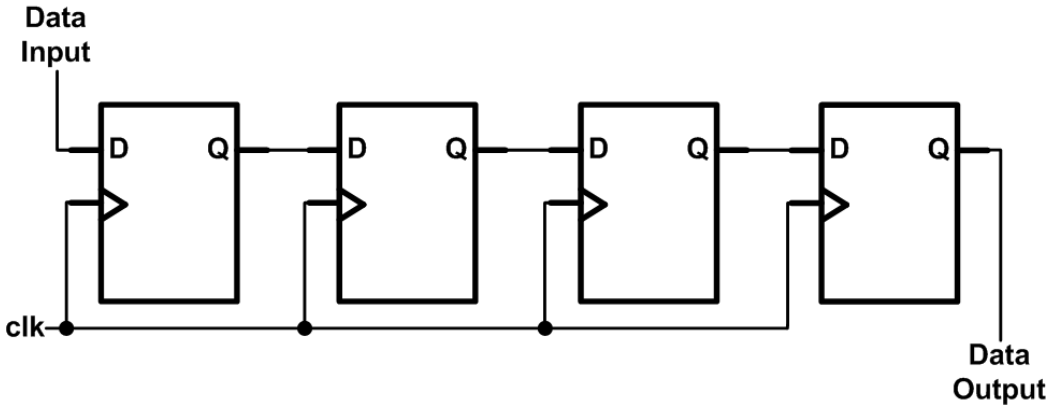
Sequential Circuits from Gates: 4 bit register

4 bit register





Four bit register



Serial in serial out shift register

Sequential Circuits from Gates: Memory from registers

Memory from registers