Derived Logic Gates and Truth Tables

Part 7b of
"Electronics and Telecommunications"
A Fairfield University E-Course
Powered by LearnLinc

Module: Digital Electronics
(in two parts)

- Text: "Digital Logic Tutorial ," Ken Bigelow, http://www.play-hookey.com/digital/
- References:
  - "Electronics Tutorial", part 10 (Thanks to Alex Pounds) http://doctord.dyndns.org:8000/courses/Topics/Electronics/Alex_Pounds/Index.htm
- Contents:
  - 7 – Digital Electronics 1
    - 5 on-line sessions plus one lab and a quiz
  - 8 – Digital Electronics 2
    - 5 on-line sessions plus one lab and a quiz
- Mastery Test part 4 follows this Module

Section 7: Digital Electronics 1

- Logic gates and Boolean algebra
- Truth Tables
- Binary numbers
- Memory
- Flip-Flops

Section 8: Digital Electronics 2

- Clocks and Counters
- Shift Registers
- Decoders
- Multiplexers & Demultiplexers
- Sampling

- **MT4**

Section 7 Schedule

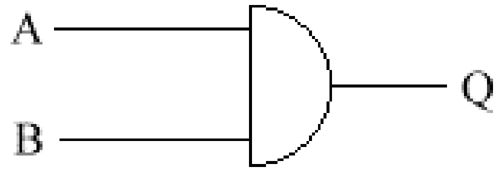
Session 7a	03/05	Introduction: Binary, Logic Gates and Boolean	Alex Pounds: Part 10 "Ken B": Home, Basic Gates, & Boolean Algebra
Session 7b	**03/10**	**Logic Gates and Truth Tables**	**Alex Pounds: Part 10** **"Ken B": Derived Gates, Xor**
Session 7c	03/12	Binary numbers	"Keb B": Binary Addition
Session 7d	03/17	Memory: Registers, RAM & ROM	"Ken B": RS Nand Latch, Clocked RS Latch, D Latch
Session 7e (Lab - 03/22, Sat.)	03/19	Pulses, Clocks and Flip-Flops	"Ken B": RS Flip-Flop, JK Flip-Flop, D Flip-Flop, Flip-Flop Symbols
Session 7f (Quiz 7 due 03/30)	03/24	Review for Quiz 7	
Session 7g	03/31	Quiz Results	

Review

- Binary
  - 1, “True”, “On”, “High” (5 volts in electronics)
  - 0, “False”, “Off”, “Low” (0 volts in electronics)
- Basic Logic Gates
  - AND, OR, NOT
- Truth Tables:
  - Enumerate outputs for all input combinations
- Boolean Algebra
  - Named Variables: True or False
  - Expressions: Equations describing relationships

Basic Logic Gates

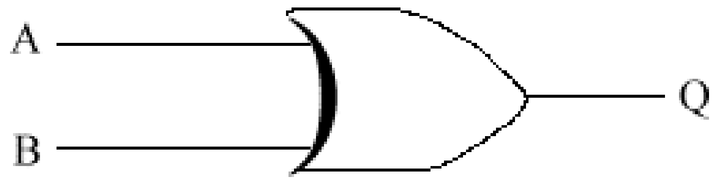
- AND



  - Q is True when both A AND B are True
  - Q = A*B

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

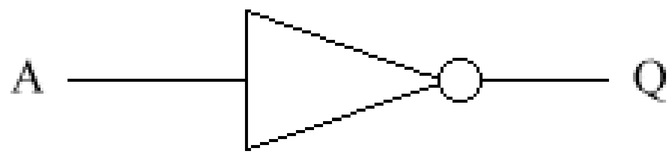
- OR



  - Q is True when either A or B is True
  - Q = A+B

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

- NOT



  - Q is true when A is false and false when A is true
  - Q = $\overline{A}$ (or A′)

A	Q
0	1
1	0

Boolean operators

- Complement: X¢ (opposite of X)
- AND: X × Y
- OR: X + Y

binary operators, described functionally by truth table.

X	Y	X AND Y
0	0	0
0	1	0
1	0	0
1	1	1

X	Y	X OR Y
0	0	0
0	1	1
1	0	1
1	1	1

X	NOT X
0	1
1	0

Theorems

(T1)	$X + 0 = X$	(T1′)	$X \cdot 1 = X$	(Identities)
(T2)	$X + 1 = 1$	(T2′)	$X \cdot 0 = 0$	(Null elements)
(T3)	$X + X = X$	(T3′)	$X \cdot X = X$	(Idempotency)
(T4)	$(X')' = X$			(Involution)
(T5)	$X + X' = 1$	(T5′)	$X \cdot X' = 0$	(Complements)

More Theorems

(T6)	$X + Y = Y + X$	(T6′)	$X \cdot Y = Y \cdot X$	(Commutativity)
(T7)	$(X + Y) + Z = X + (Y + Z)$	(T7′)	$(X \cdot Y) \cdot Z = X \cdot (Y \cdot Z)$	(Associativity)
(T8)	$X \cdot Y + X \cdot Z = X \cdot (Y + Z)$	(T8′)	$(X + Y) \cdot (X + Z) = X + Y \cdot Z$	(Distributivity)
(T9)	$X + X \cdot Y = X$	(T9′)	$X \cdot (X + Y) = X$	(Covering)
(T10)	$X \cdot Y + X \cdot Y' = X$	(T10′)	$(X + Y) \cdot (X + Y') = X$	(Combining)
(T11)	$X \cdot Y + X' \cdot Z + Y \cdot Z = X \cdot Y + X' \cdot Z$			(Consensus)
(T11′)	$(X + Y) \cdot (X' + Z) \cdot (Y + Z) = (X + Y) \cdot (X' + Z)$			

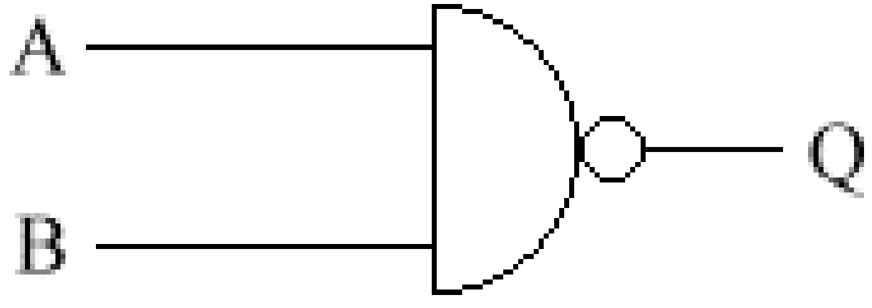
Derived Logic Gates

- Derived gates are those made out of simple combinations of the basic gates.
- Common derived functions
  - NAND: inverted AND
  - NOR: inverted OR
  - XOR: the exclusive or A or B but not A and B
- These derived gates are the ones seen most often.

NAND Gate

- Q is False when both A AND B are True and True otherwise
  - $Q = \overline{(A*B)} = (A*B)'$
  - It can have any number of inputs
  - Note that this is an AND followed by a NOT

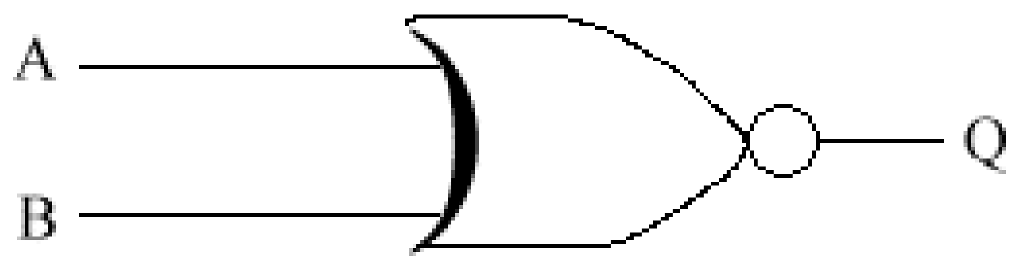
A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0



NOR Gate

- Q is False when either A or B is True
  - $Q = \overline{(A+B)} = (A+B)'$
  - It can have any number of inputs
  - Note that this is an OR followed by a NOT

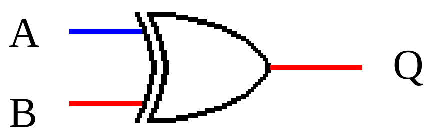
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

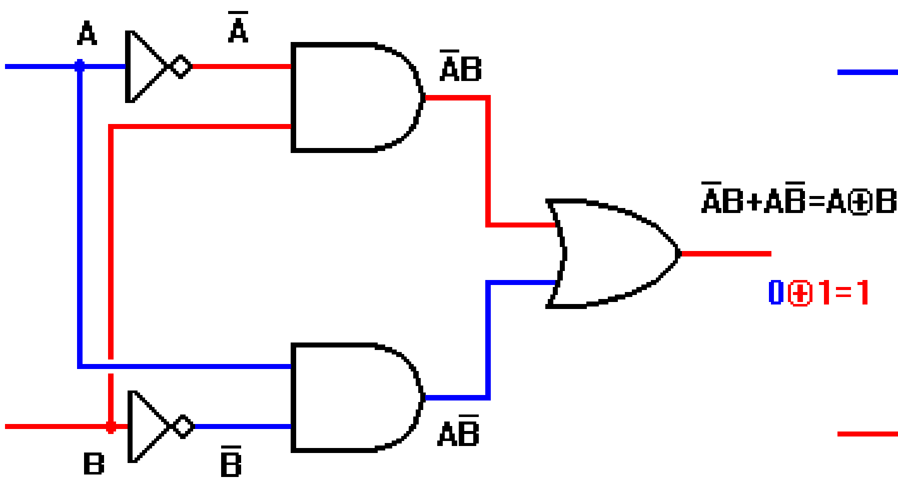


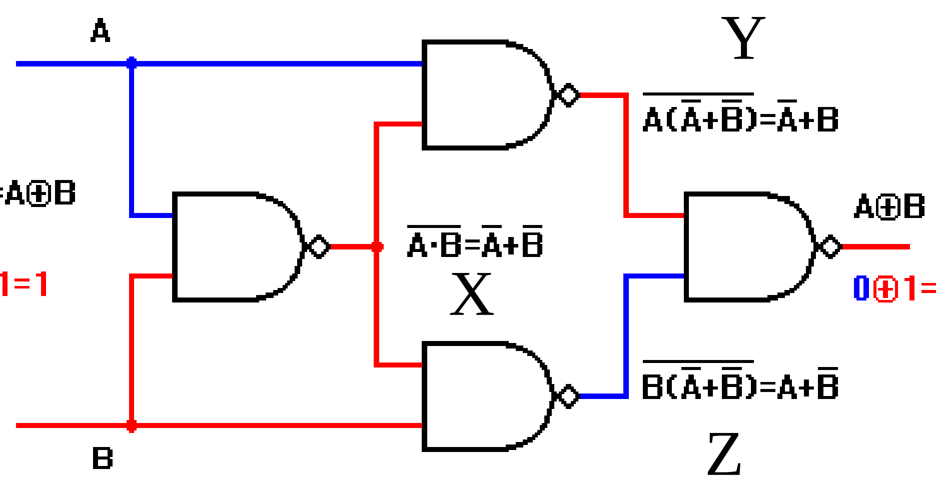
XOR: The Exclusive OR

- Q is True when either A OR B is True, but not when both A AND B are True
  - $Q = \overline{A}*B + A*\overline{B} = A \oplus B$

A	B	X	Y	Z	Q
0	0	1	1	1	0
0	1	1	1	0	1
1	0	1	0	1	1
1	1	0	1	1	0







Simulation

- We'll again go to www.play-hookey.com/digital to see these gates in action

Section 7 Schedule

Session 7a	03/05	Introduction: Binary, Logic Gates and Boolean	"Hookey": Home, Basic Gates, & Boolean Algebra Alex Pounds: Part 10
Session 7b	03/10	Logic Gates and Truth Tables	"Hookey": Derived Gates, Xor
Session 7c	**03/12**	**Binary numbers**	**"Hookey": Binary Addition**
Session 7d	03/17	Memory: Registers, RAM & ROM	"Hookey": RS Nand Latch, Clocked RS Latch, D Latch, Notes
Session 7e (Lab - 03/22, Sat.)	03/19	Pulses, Clocks and Flip-Flops	"Hookey": RS Flip-Flop, JK Flip-Flop, D Flip-Flop, Flip-Flop Symbols,
Session 7f (Quiz 7 due 03/30)	03/24	Review for Quiz 7	
Session 7g	03/31	Quiz Results	