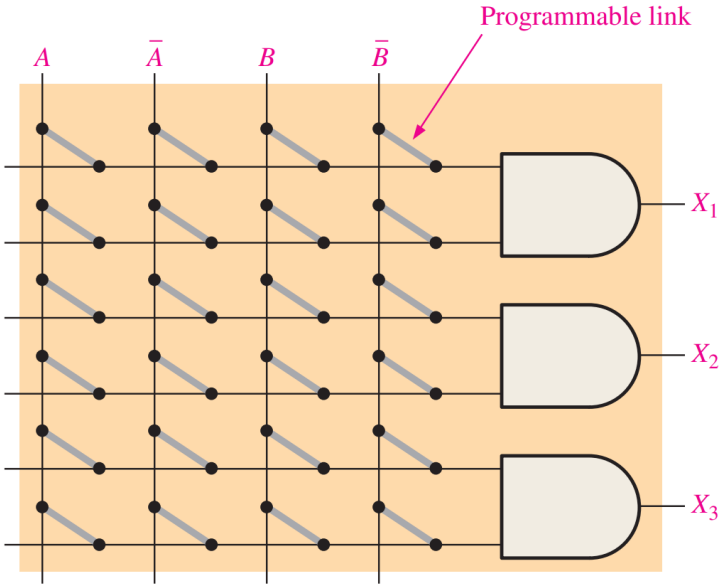
CPE201
Digital Design

By Benjamin Haas

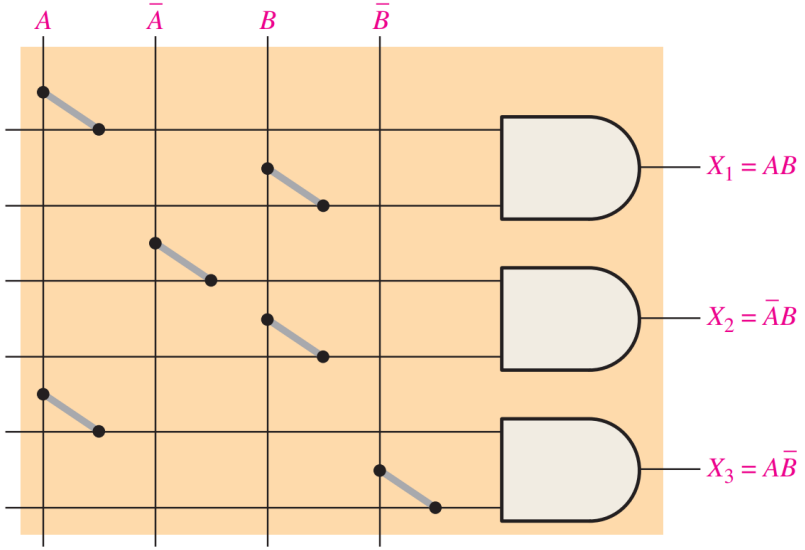
Class 7: PLDs, Boolean Laws, and Equipment

University of Nevada, Reno

PLDs



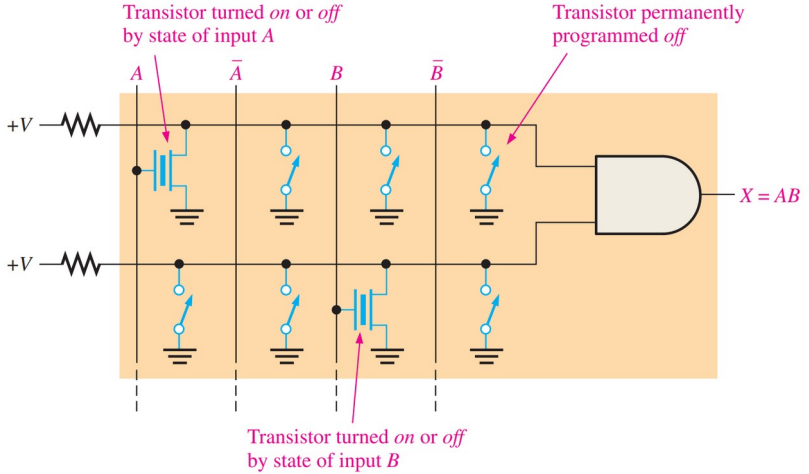
(a) Unprogrammed

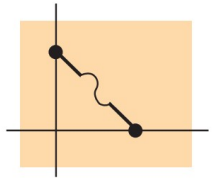


(b) Programmed

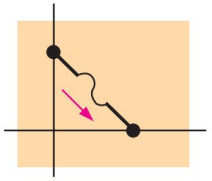
OTPs

- One Time Programma
- Many types
- Burn it out!

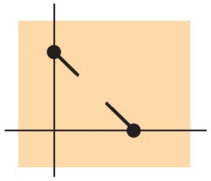




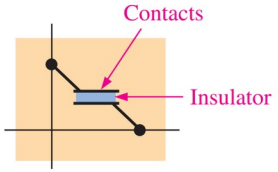
(a) Fuse intact before programming



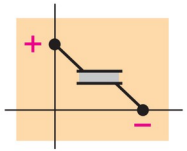
(b) Programming current



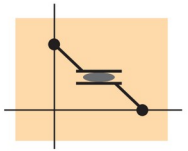
(c) Fuse open after programming



(a) Antifuse is open before programming.



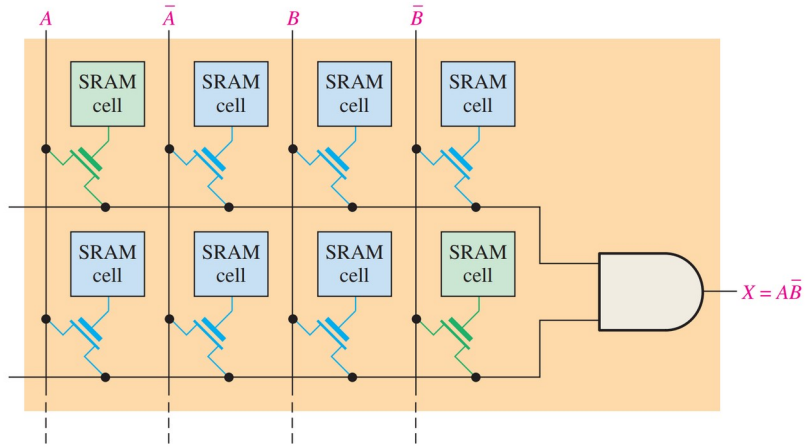
(b) Programming voltage breaks down insulation layer to create contact.



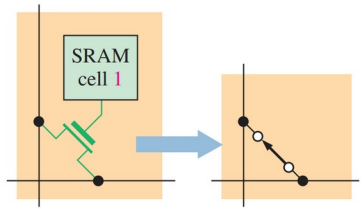
(c) Antifuse is effectively shorted after programming.

Reprogrammable

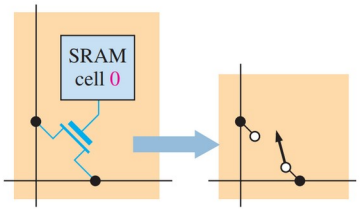
- Different tech
- Different cost
  - More circuitry



(a) SRAM-based programmable array



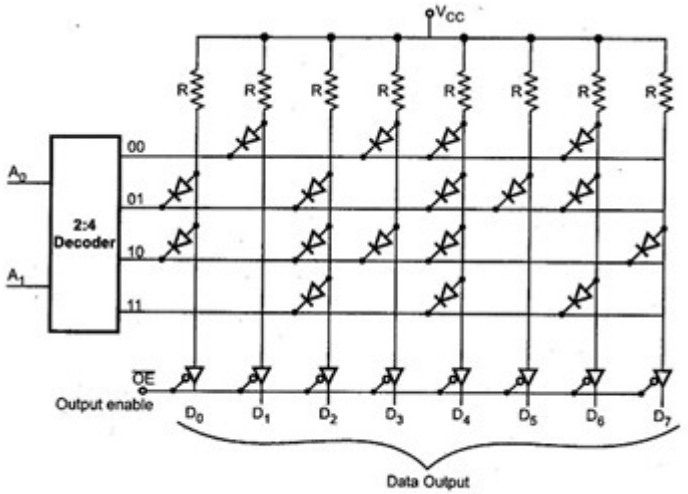
(b) Transistor *on*



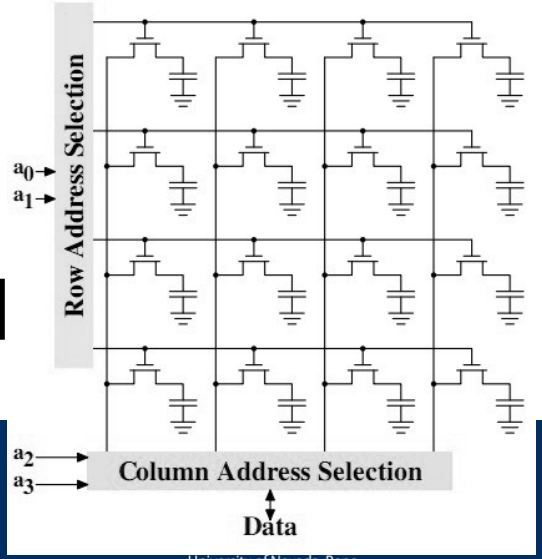
(c) Transistor *off*

ROM/RAM

- Same concept as PLD
- Address lines in
- Stores data
- RAM vs ROM



Simple four byte diode ROM

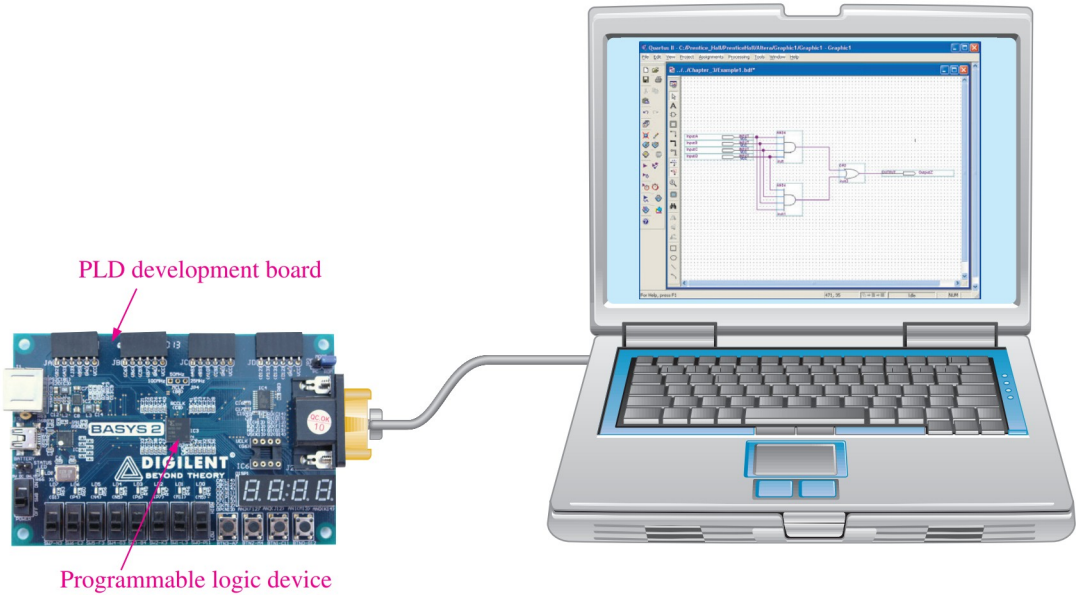


Programming

Tape-out and Packing Handler

Programming/Debugging

- Development
- In-system
  - JTAG
  - SWD



Boolean Addition

- Same as OR
  - Remember that here 0=FALSE, 1=TRU

Truth tables:

a	b	AND
0	0	0
0	1	0
1	0	0
1	1	1

a	b	OR
0	0	0
0	1	1
1	0	1
1	1	1

a	NOT
0	1
1	0

Boolean Multiplication

- Same as AND

Truth tables:

a	b	AND
0	0	0
0	1	0
1	0	0
1	1	1

a	b	OR
0	0	0
0	1	1
1	0	1
1	1	1

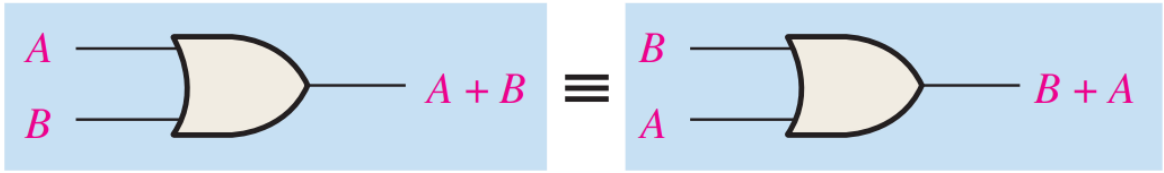
a	NOT
0	1
1	0

Boolean Laws

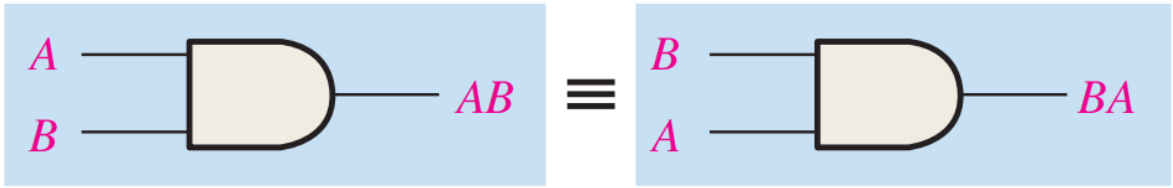
- Commutative Laws
- Associative Laws
- Distributive Laws
- 12 Rules for Simplification
- Why?
  - Not every system has these laws, i.e. matrices

Commutative Laws

- A + B = B + A

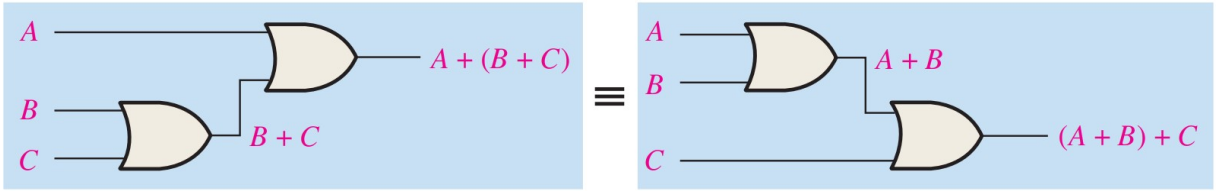


- AB = BA

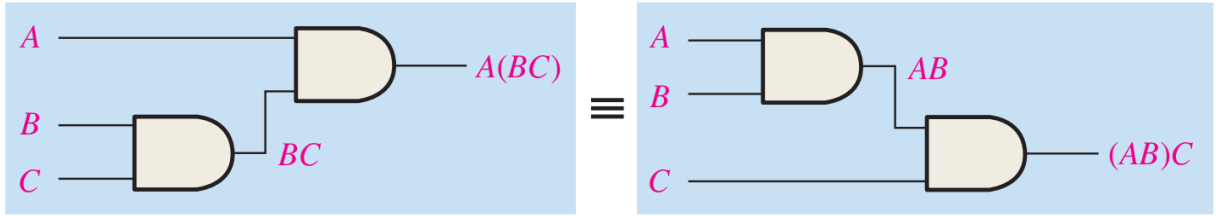


Associative Laws

- A + (B + C) = (A + B) + C

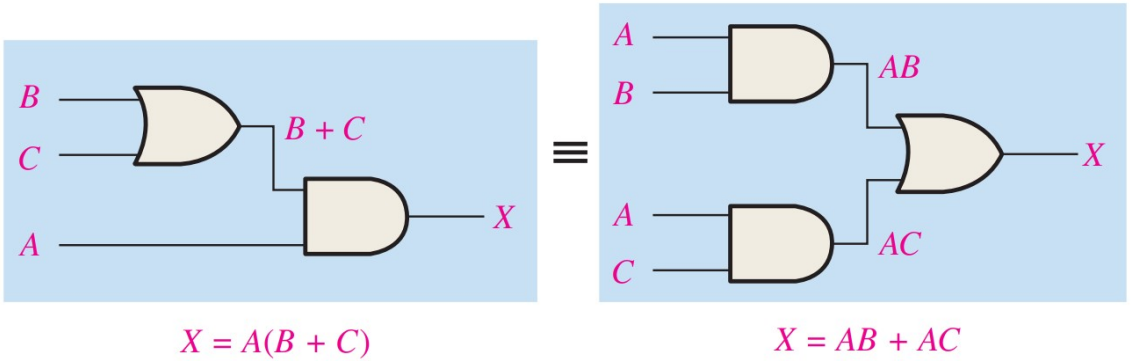


- A(BC) = (AB)C



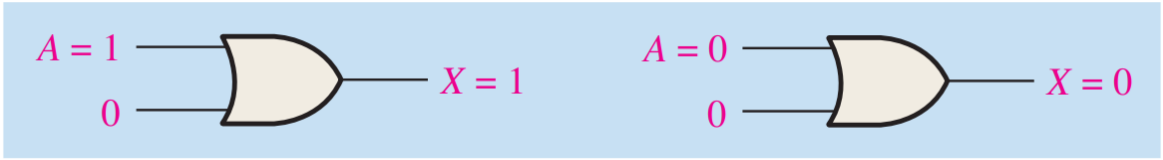
Distributive Laws

- A(B + C) = AB + AC



12 Rules for Simplification

- 1. A + 0 = A

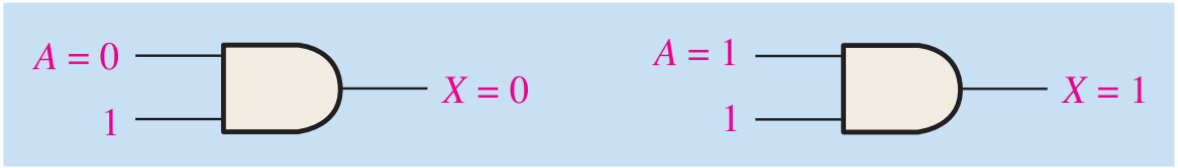


- 2. A + 1 = 1

12 Rules for Simplification

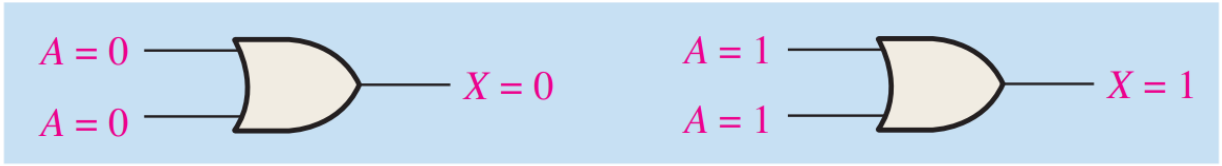
- 3. A • 0 = 0

- 4. A • 1 = A

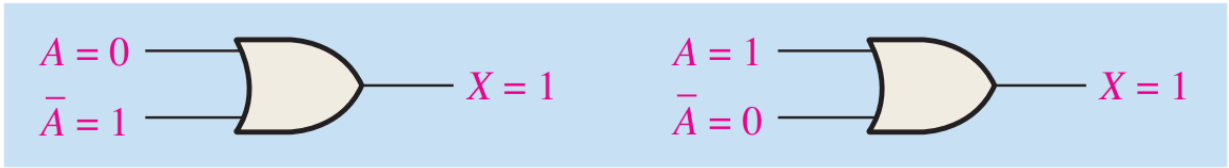


12 Rules for Simplification

- 5. A + A = A

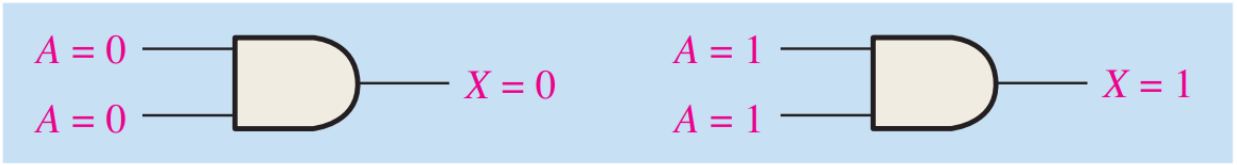


- 6. A + A’ = 1

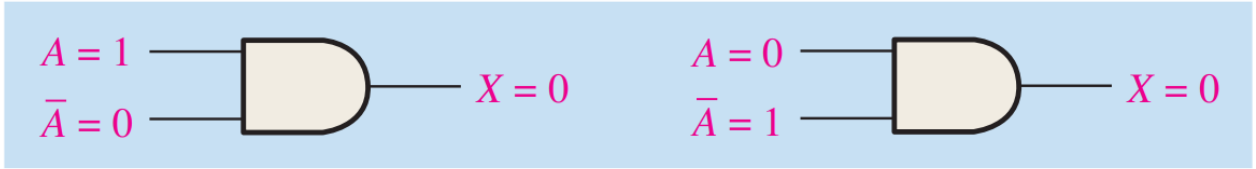


12 Rules for Simplification

- 7. A • A = A

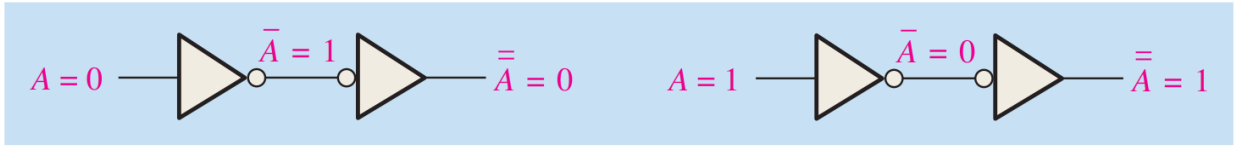


- 8. A • A’ = 0



12 Rules for Simplification

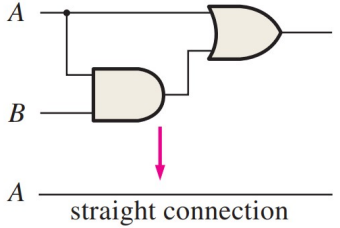
- 9. A” = A



- 10. A + AB = A

A	B	AB	A + AB
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

equal

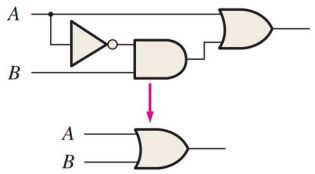


12 Rules for Simplification

- 11. A + A'B = A + B

A	B	$\bar{A}B$	$A + \bar{A}B$	$A + B$
0	0	0	0	0
0	1	1	1	1
1	0	0	1	1
1	1	0	1	1

equal



- 12. (A + B)(A + C) = A + BC
  - Also follows from distribution, Rule 7, and Rule 10
  - Diagram in book

Equipment

- Test and debugging equipment
- Debugging origin
  - Literal bugs

Multimeter

- Your best friend!
  - Voltage
  - Current
  - Resistance
  - Continuity

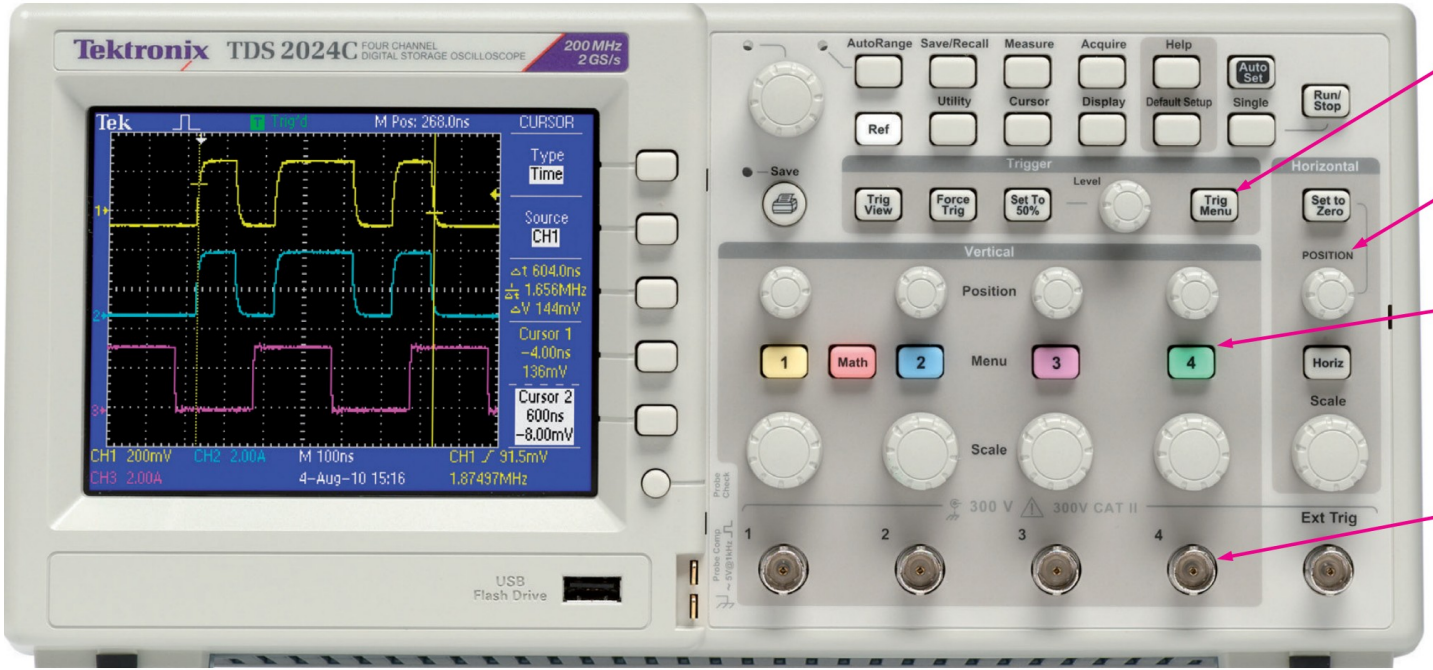
(a) Bench-type DMM

(b) Handheld DMM

Oscilloscope

- Oscope or scope
  - Measures and displays signals
- The fastest ADC you'll typically use

Oscope



Trigger controls

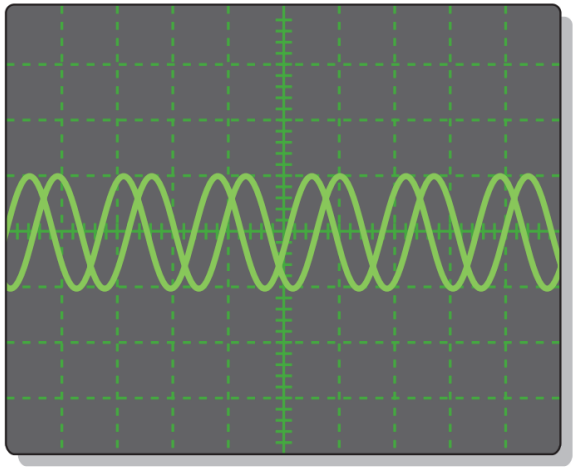
Horizontal controls

Vertical controls

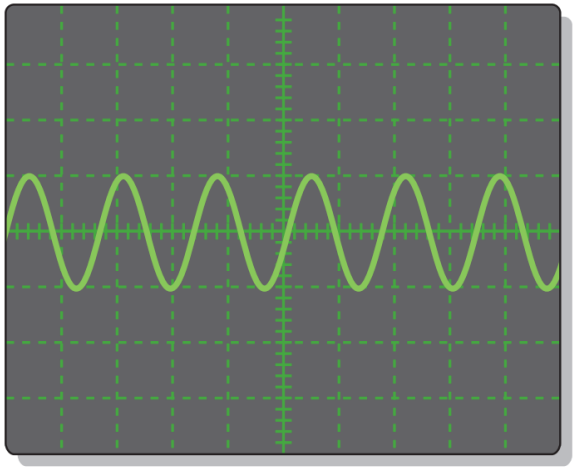
Channel inputs

Oscope

- Vertical and Horizontal controls
- Triggers



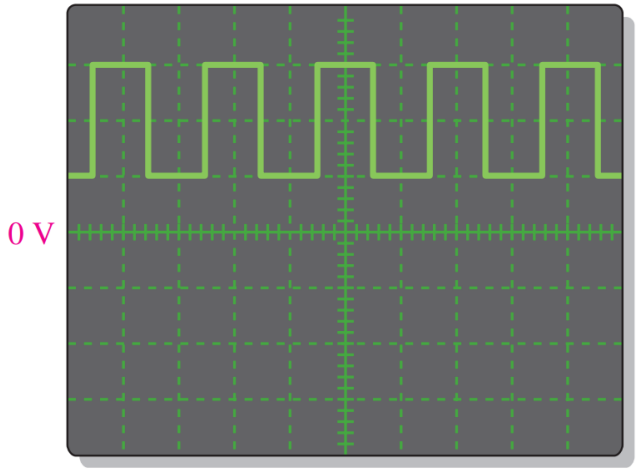
(a) Untriggered waveform display



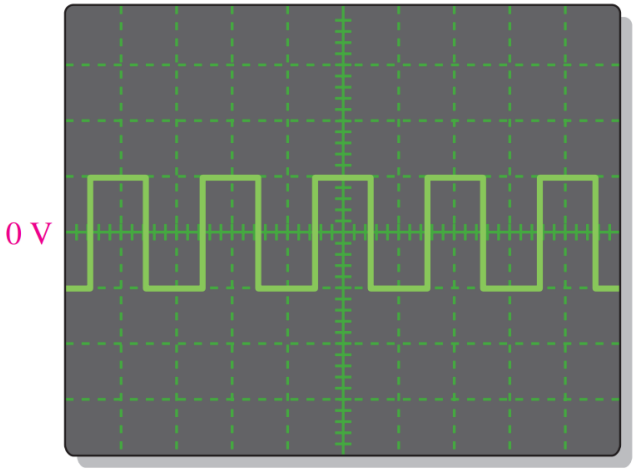
(b) Triggered waveform display

Oscope

- AC vs DC coupling



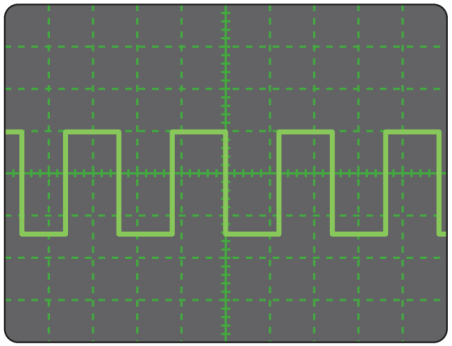
(a) DC coupled waveform



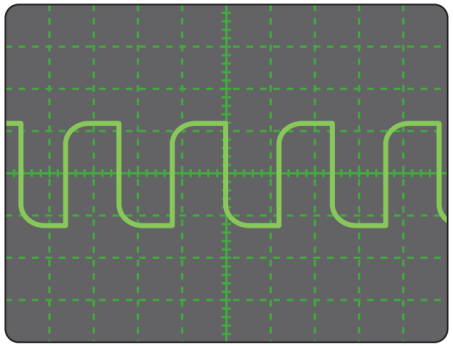
(b) AC coupled waveform

Oscope

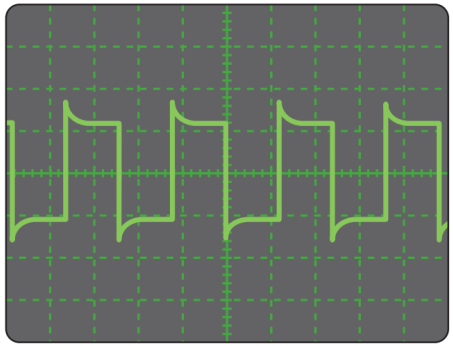
- Compensation and Loading
- Shopping cart example



Properly compensated



Undercompensated



Overcompensated

Probes

Voltage

Current

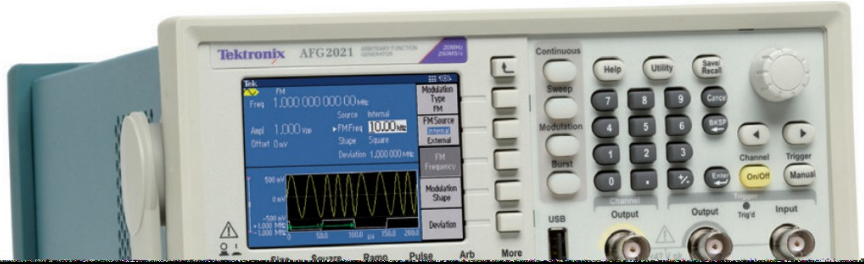
Multi

Power Supply

- DC Voltages
  - Circuit power
  - Very stable

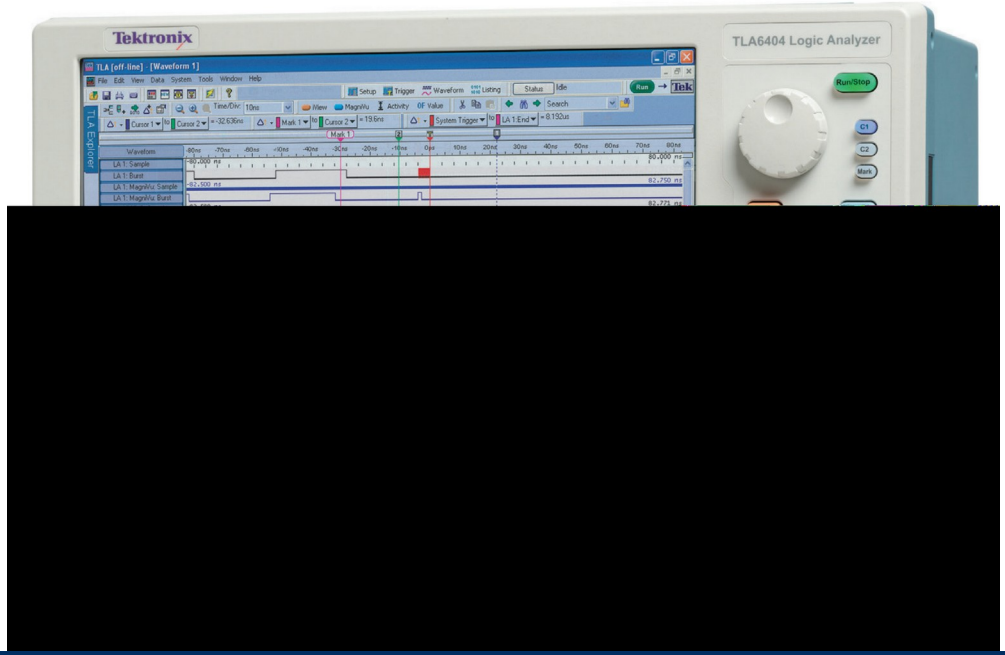
Generators

- Arbitrary vs Function



Logic Analyzer

- Oscope+
- Can measure
  - And decode!
- Costs extra



Others

- Frequency Analyzer
- RLC meters
- Fiber optics
- Anything you could want, pretty much

Reading

- This lecture
  - Sections 3.7, 1.7, 4.1-4.2
- Next lecture
  - Sections 4.3-4.6