University of Virginia

Department of Physics

Physics 606: How Things Work II

Lecture #23 Slides:
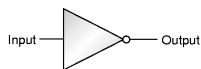
Computers II

and

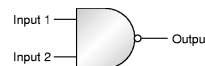## Radios

Inverter

- Takes one input bit, provides one output bit
- Output bit is inverse of input bit

Input ——▷o—— Output

Input	Output
1	0
0	1

Not-And (NAND)

- Takes two input bits, provides one output bit
- Output is inverse of logical "and" of input bits

Input 1 ——
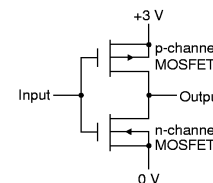Input 2 ——)o—— Output

Input 1	Input 2	Output
1	1	0
1	0	1
0	1	1
0	0	1

CMOS Logic

- Bits are represented by charge
- "1" is represented by positive charge
- "0" is represented by negative or no charge
- Logic is built from n-channel and p-channel MOSFETS in complementary pairs

CMOS Inverter

- Input charge delivered to two complementary MOSFETs
- Positive charge on input delivers negative charge to output
- Vice Versa

+3 V
p-channel MOSFET
Input ——— Output
n-channel MOSFET
0 V

CMOS NAND

- Positive on both inputs delivers negative charge to output
- Negative on either input delivers positive charge to output

+3 V
Input 1
Output
Input 2
0 V
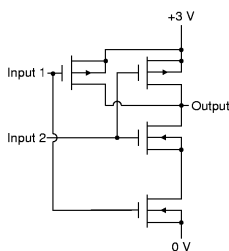
Personal Computers

- Use CMOS logic for computations
- Use charge-based memory for fast storage
- Use magnetization or optical for slow storage
- Use light, radio, current, or sound for network

Speed Limits

- Bits move no faster than the speed of light
- Speed of light is 1 foot per nanosecond
- During one PC cycle, bits can move 1 foot
- Processors can't be bigger than 1 foot

Question:

Today, the fastest PCs run at roughly 1.5 GHz. Someday, computers may run at 1,000,000 GHz. Compared to present computers, those high-speed ones would have to be

1. much larger.
2. much smaller.
3. about the same size.

Radio

Question:

If you took an electrically charged ball and shook it up and down rapidly, charges in a nearby metal object would move in response. How far away could that metal object be and still respond?

- 1 meter
- 1 kilometer
- The other side of the universe

Observations About Radio

- Transmit sound long distances without wires
- Involve antennas
- Seem to involve electricity and magnetism
- Reception depends on antenna positioning
- Reception weakens with distance
- Two styles of radio: AM and FM

Electromagnets and Energy

- Electric and magnetic fields contain energy
- An electromagnet stores magnetic energy
- Electromagnet consumes energy as it turns on
– Current temporarily experiences a voltage drop
- Electromagnet releases energy as it turns off
– Current temporarily experiences a voltage rise
- Electromagnet opposes current charges

Inductors

•Inductors are electromagnets
•Inductors store magnetic energy
•Inductors oppose changes in current

Tank Circuit

•Inductor & Capacitor share energy
•Charge flows back and forth through inductor
•Energy shifts back and forth between the two devices