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

Not-And (NAND)
- Takes two input bits, provides one output bit
- Output is inverse of logical “and” of input bits

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

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

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. 1 meter
2. 1 kilometer
3. 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