Lecture 14

Relays
Relays

- Relays are electrically actuated switches
  - Mechanical relays
  - Reed relays
  - Solid-state relays
- A relay consists of an electromagnetic coil and one or more pairs of contacts
Mechanical Relays

• Designed for high currents
  – Typically from 2A to 15A
• Relatively slow switching
  – 10ms to 100ms

Contact switch
Common Symbols for Relays

SPST (normally open)
Single Pole, Single Throw

SPST (normally closed)

SPDT

DPST (normally open)

DPST (normally closed)

DPDT
Notes About Relays

- To make a relay change states, the voltage across of its magnetic coil should be at least within $\pm 25$ percent of the relay’s specified control voltage rating ($V_c \pm 0.25 \times V_c$)

- Sudden changes in current will create voltage spike, to avoid this is to use transient suppressors
Electromechanical Relay
Relays with BS2

Using an NPN transistor to drive a relay
Reed Relays

- Designed for moderate currents
  - Typically from 500mA to 1A
- Moderately fast switching
  - 0.2ms to 2ms
Description

• Contains two magnetizable and electrically conductive reeds
• Magnetic field will cause the contacts to pull together
Solid State Relays

- Contains no moving parts
- Wide range of current ratings
  - from a few μA to 100A
- Extremely fast switching
  - 1 to 100 ns
Solid State Relay with AC

Extremely caution with 120V AC !!
## Relay Experiments

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Lecture 15

DC Motor
DC Motor

- DC motors are
  - Simple two-lead
  - Electrically controlled
- The voltage range of the DC motor is
  - 1.5V ~ 48V
DC Motor: How It Works

When electric current passes through a coil in a magnetic field, the magnetic force produces a torque which turns the DC motor.

Electric current supplied externally through a commutator acts perpendicular to both wire and magnetic field.

Magnetic force $F = I \times B$.
Turning a DC Motor On/Off

![Diagram of a DC motor circuit with BS2 transistor and power supply labeled B1 1.5 to 18 V]
DC Motor Speed Control 1

• When the voltage applied to a DC motor
  – Lower than nominal voltage → Motor runs slower
  – Higher than nominal voltage → Motor runs faster

• Linear control
  – Connect a potentiometer in series with motor
  – Use a transistor (BJT/FET) as a variable resistor
DC Motor Speed Control 2

Linear control using a potentiometer in series with motor
DC Motor Speed Control 3

Linear control using a bipolar transistor
Pulse Width Modulation 1

- An efficient method to deliver controlled amount of power to loads
- Use square voltage pulses to power a load
- The amount of power deliver to load depends on the duration of each pulse

Basic PWM control
Pulse Width Modulation 2

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Pulse-Width-Modulation 3

Controlling on-time duration of a DC motor

Digital potentiometer
Pulse-Width-Modulation 4

PWM

- Full "on"
- 50% "on"
- 25% "on"
- "Accelerating"