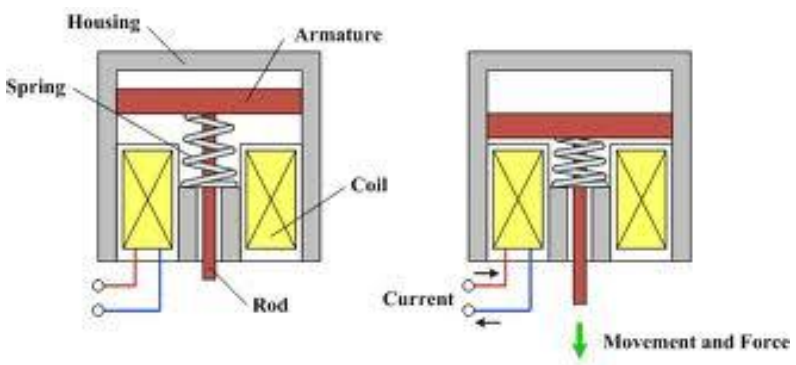
ELECTRONIC SYSTEM DESIGN

ACTUATORS

Prof. Yasser Mostafa Kadah

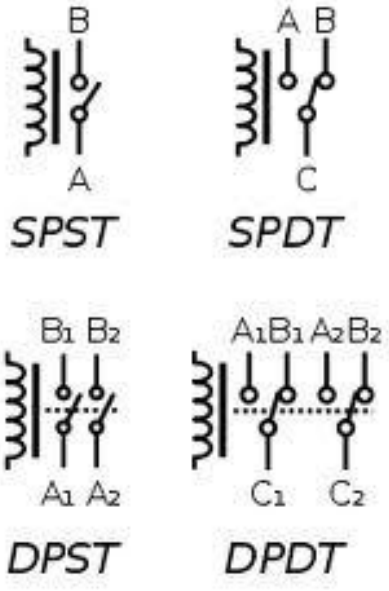
Solenoids

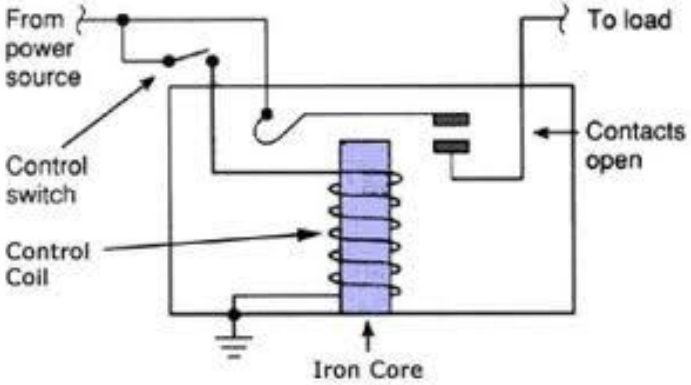
- A solenoid is an electromagnet that activates a mechanical function
  - Solenoids are used to latch safety covers closed so they can't be opened while a machine is in operation, or to unlock the doors in your car when you push the keyless entry button on the remote.
- There are two basic varieties:
  - Continuous-duty solenoids designed to be energized all the time
  - Pulse-duty solenoid designed for intermittent operation



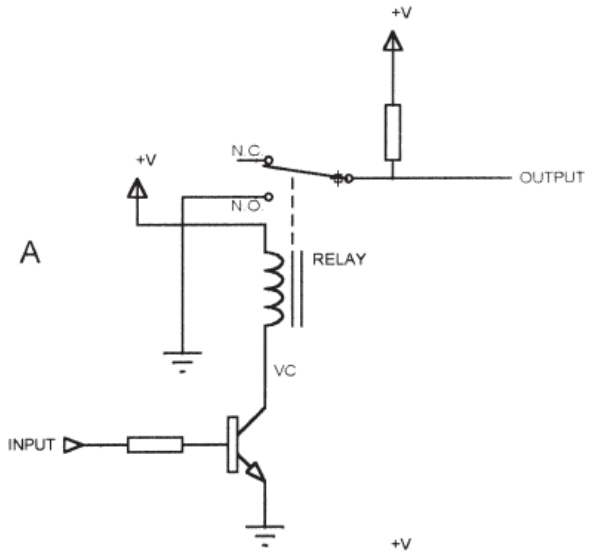
Relays

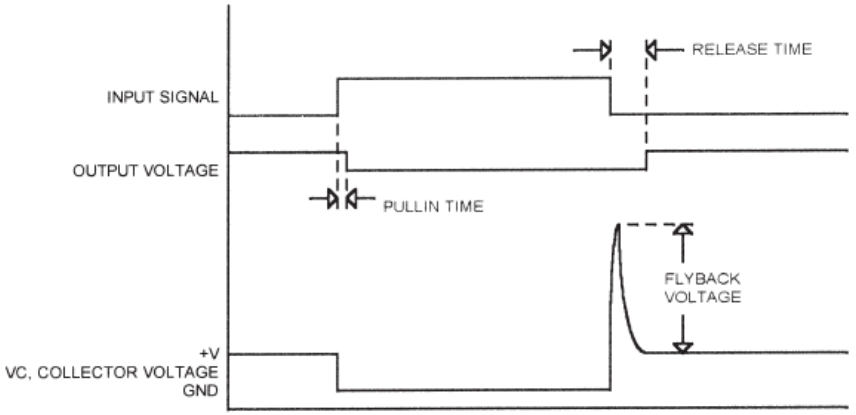
- A relay is a solenoid that operates electrical contacts. When the relay is energized, the contacts are shorted or opened, just like a mechanical switch

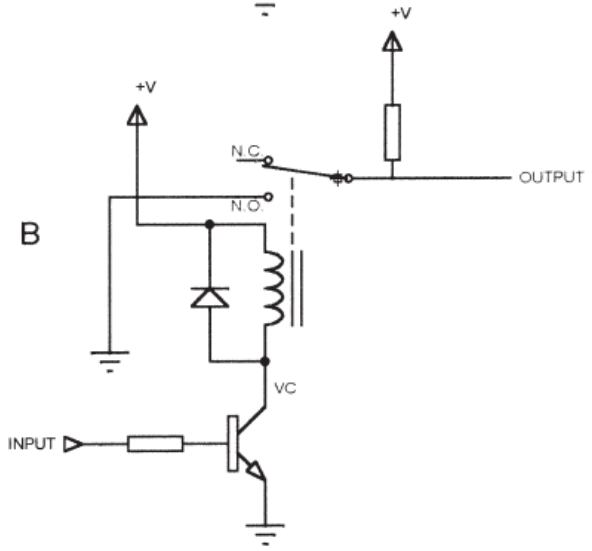


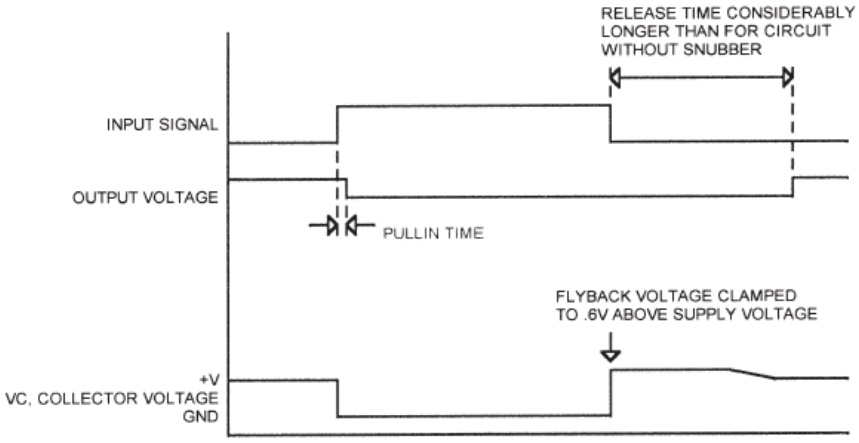


Interfacing to Solenoids and Relays





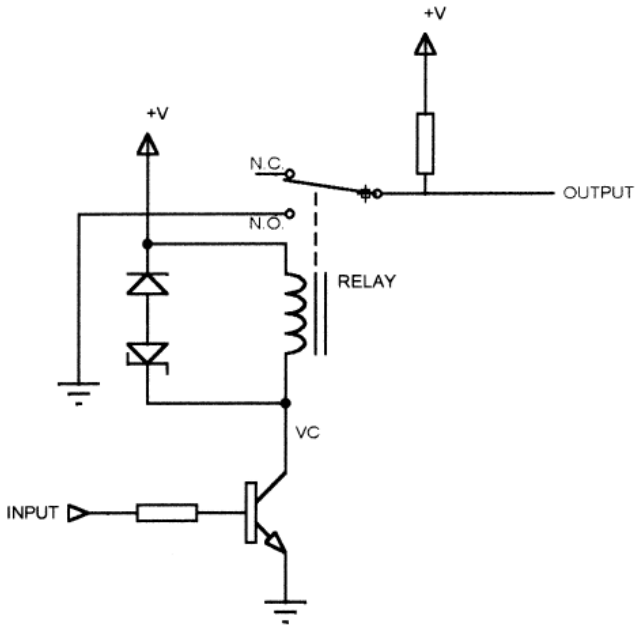


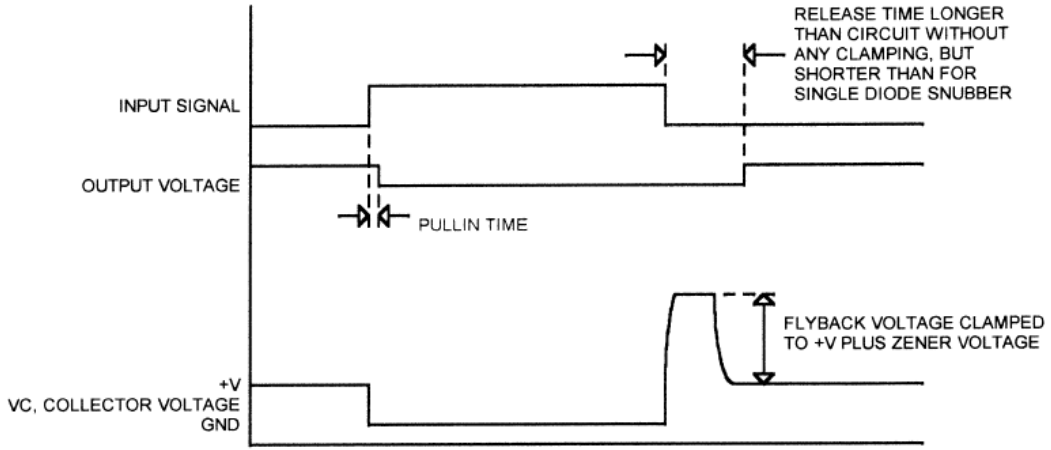


Interfacing to Solenoids and Relays

- Problems with diode clamping
  - Results in a current surge into the supply: Noise spike
  - slows the release time down
- Solution: Zener diode clamp

Clamp	*Open Time*
none	1 ms
12v zener	1.5 ms
6v zener	2.2 ms
diode	5.5 ms

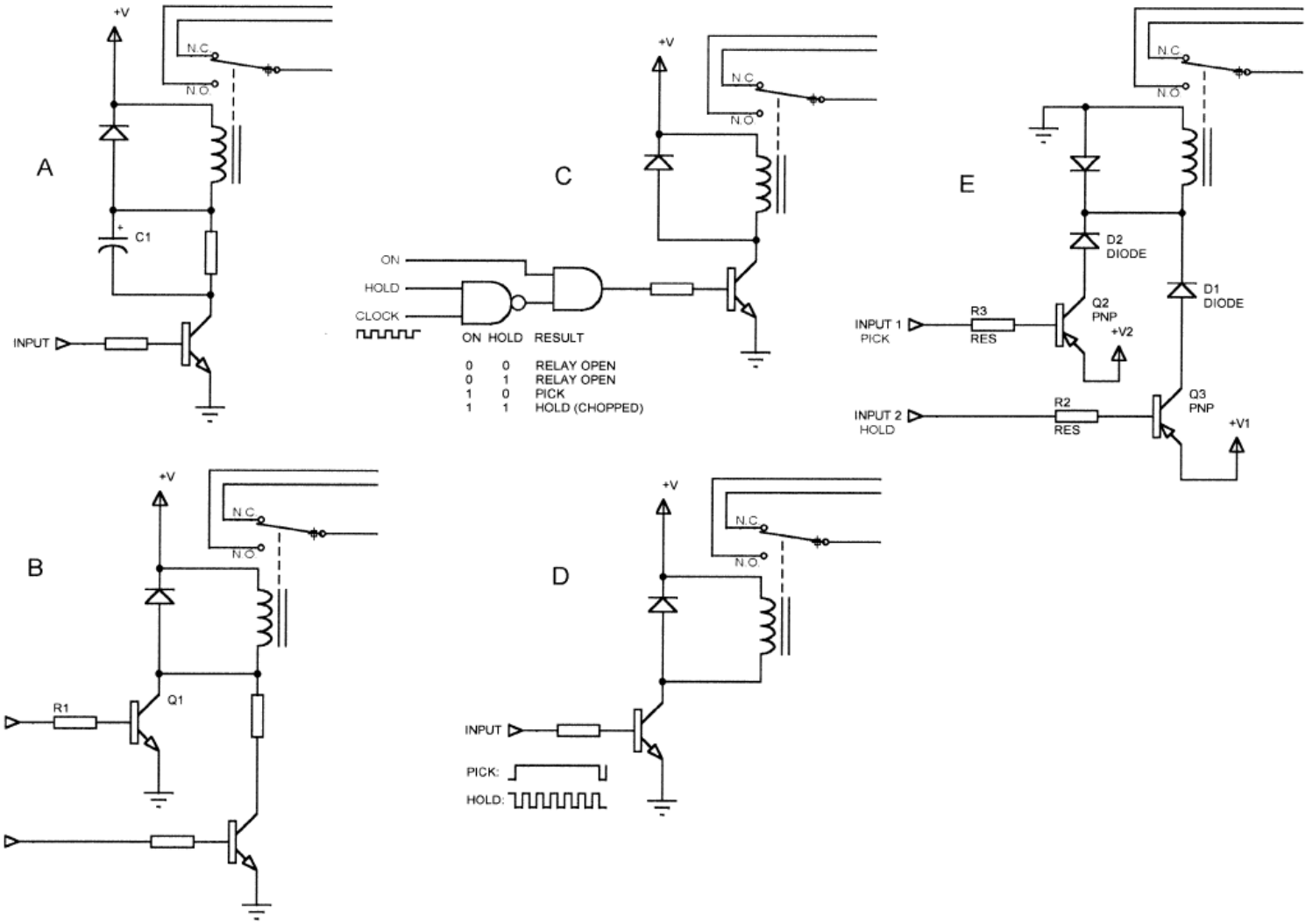




Solenoid Pick/Hold Current

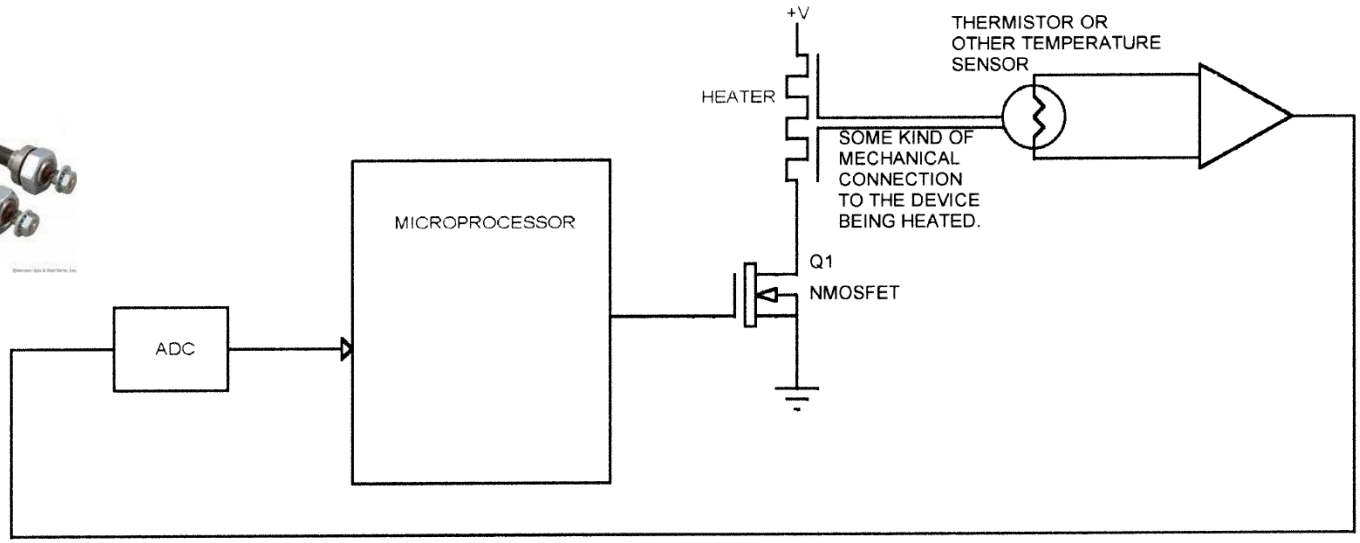
- DC current drawn by a relay has to be high enough to pull relay contacts from one end of its travel to the other
  - However, current needed to hold that position is much lower—typically 50% of the pull-in (or pick) voltage
- Smaller power supply can be used if the current is reduced once the relay contacts are pulled in, especially if several relays are to be activated at once
  - Using a lower hold current decreases the release time

Solenoid Pick/Hold Current

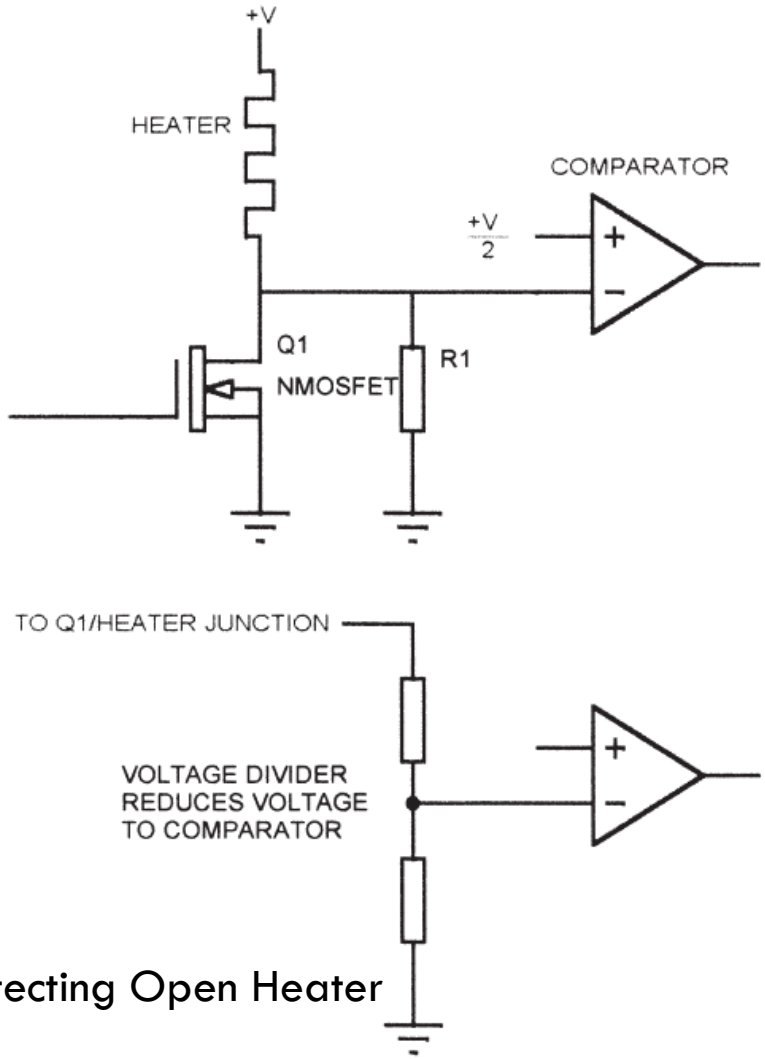


Heaters

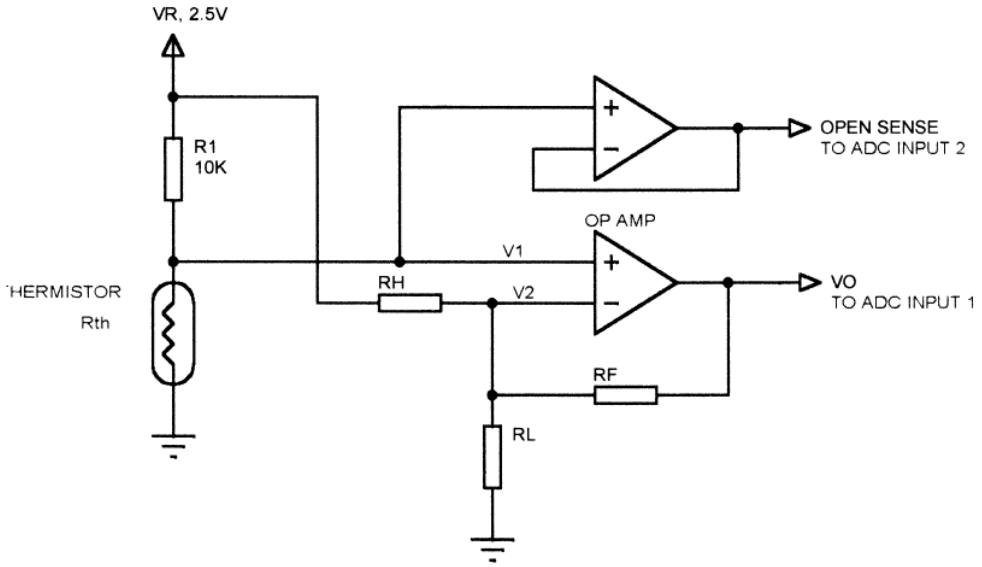
- A heater is driven much like a solenoid, usually using a transistor.
  - Most heaters have negligible inductance, so the clamping diodes are not necessary.
  - Controlled by a feedback loop, with a temperature sensor mounted somewhere to measure temperature



Detecting Open Heater / Sensor



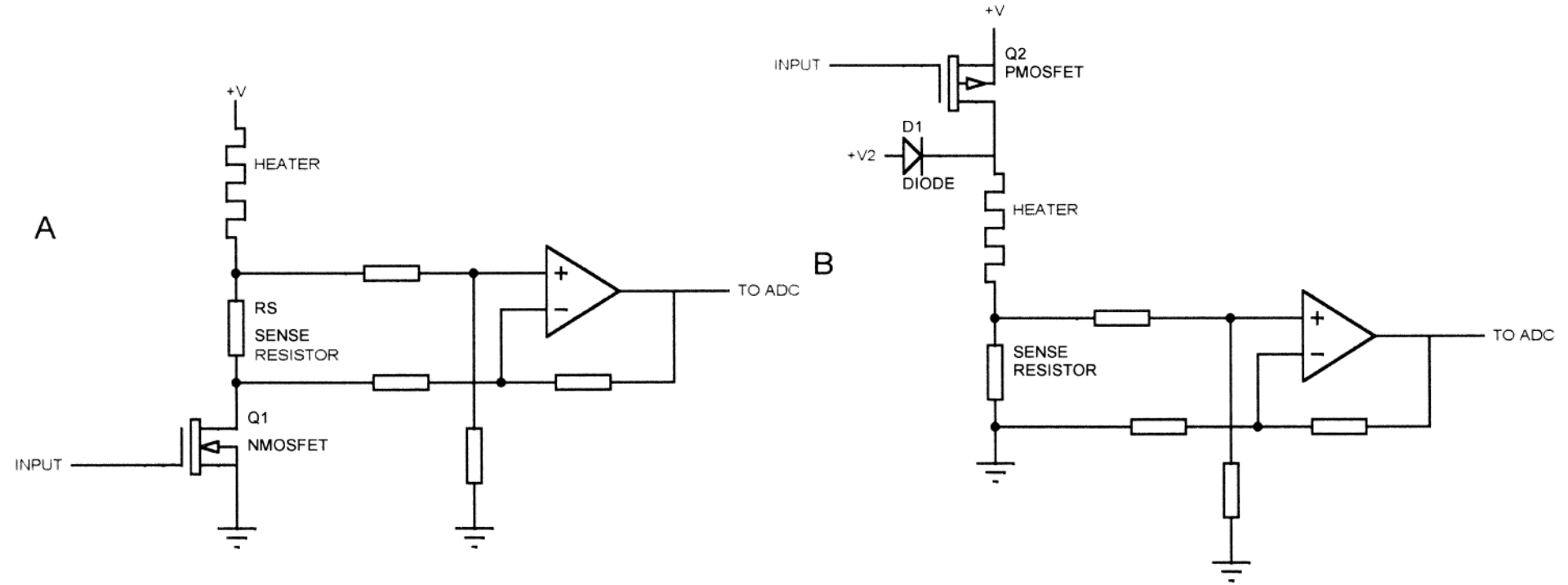
Detecting Open Heater



Detecting Open Sensor

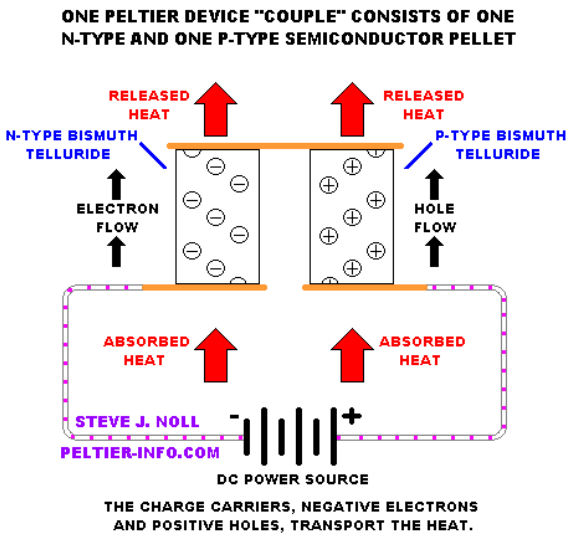
RTD Heater

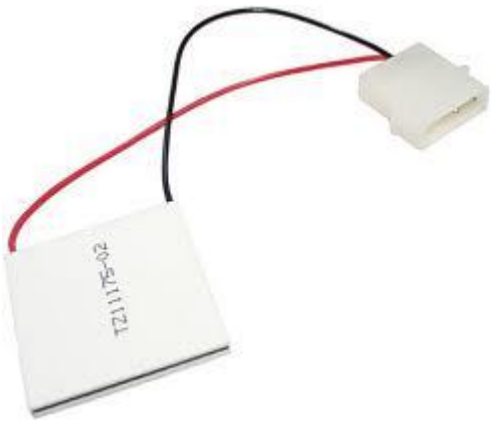
- RTD heater is a special type of heater that is composed of an RTD material, usually iron-nickel.
  - Heater element doubles as the thermistor
  - Since a thermistor is not required, overall cost is lower



Solid-State (Peltier) Cooler

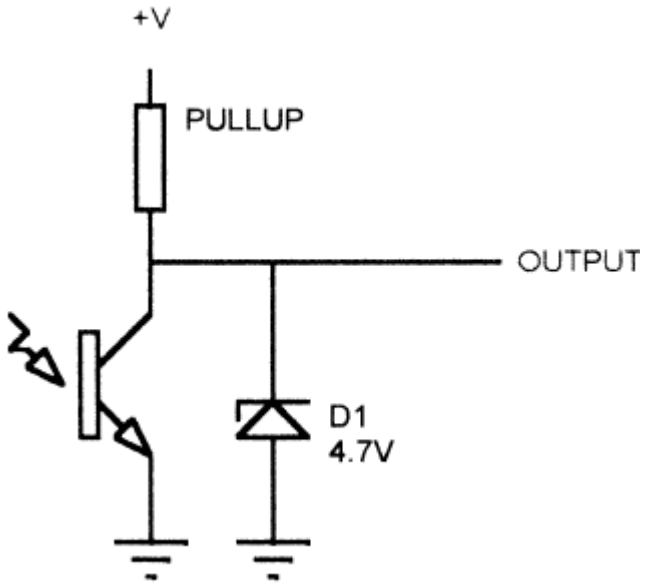
- Consists of a series of PN junctions that can draw heat from one side and exhaust heat on other side
  - A Peltier cooler can be controlled much like a heater, using a thermistor to measure the temperature
  - PWM is used with minimum PWM frequency is usually recommended, typically around 2kHz to avoid thermal stress on the semiconductor elements

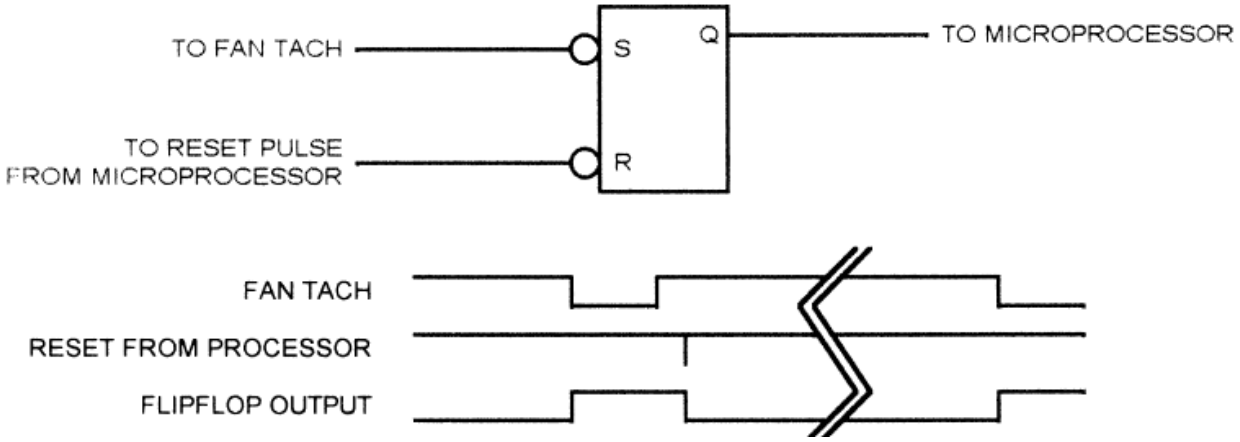




Fans

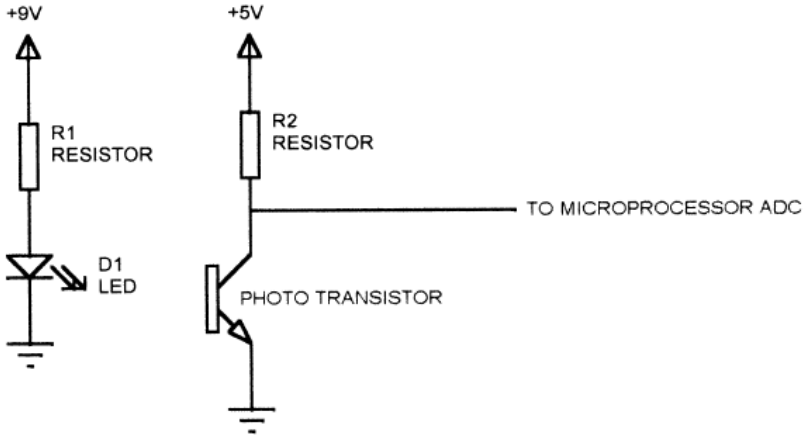
- Monitor the fan to be sure it is operating
  - Temperature sensor to see if things overheat
  - Airflow sensor near the fan to sense moving air
  - Internal sensor that generates a pulse per revolution

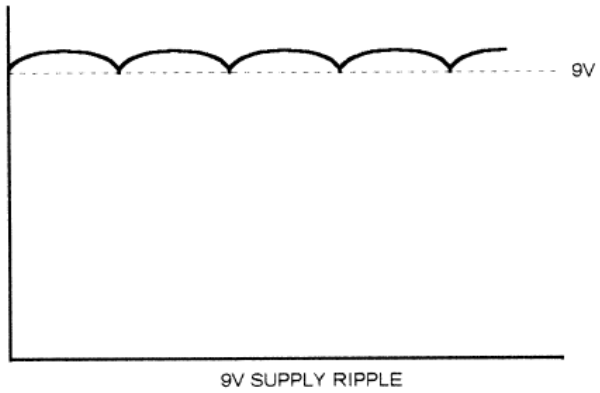


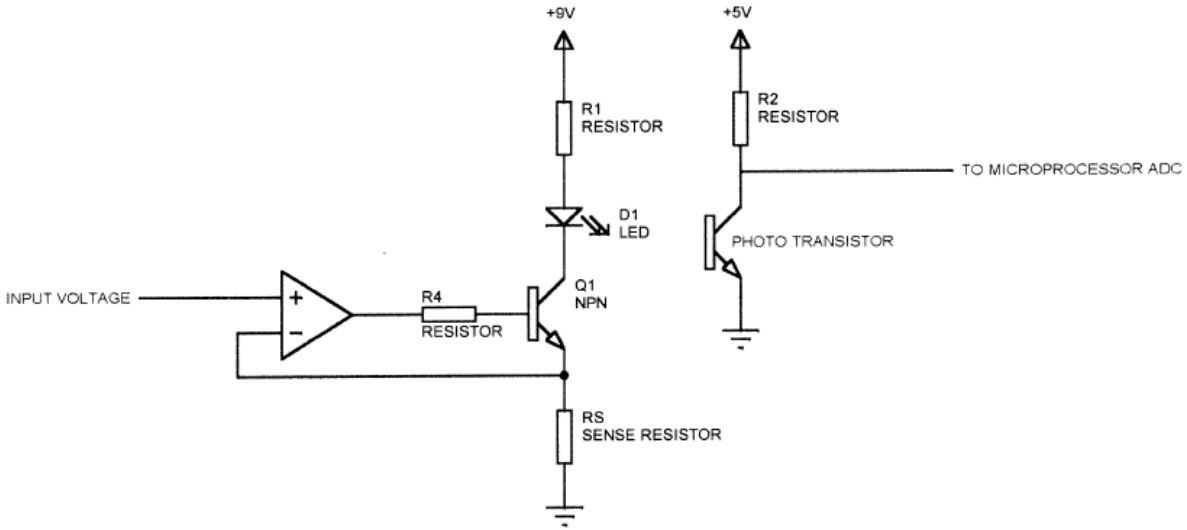


LEDs

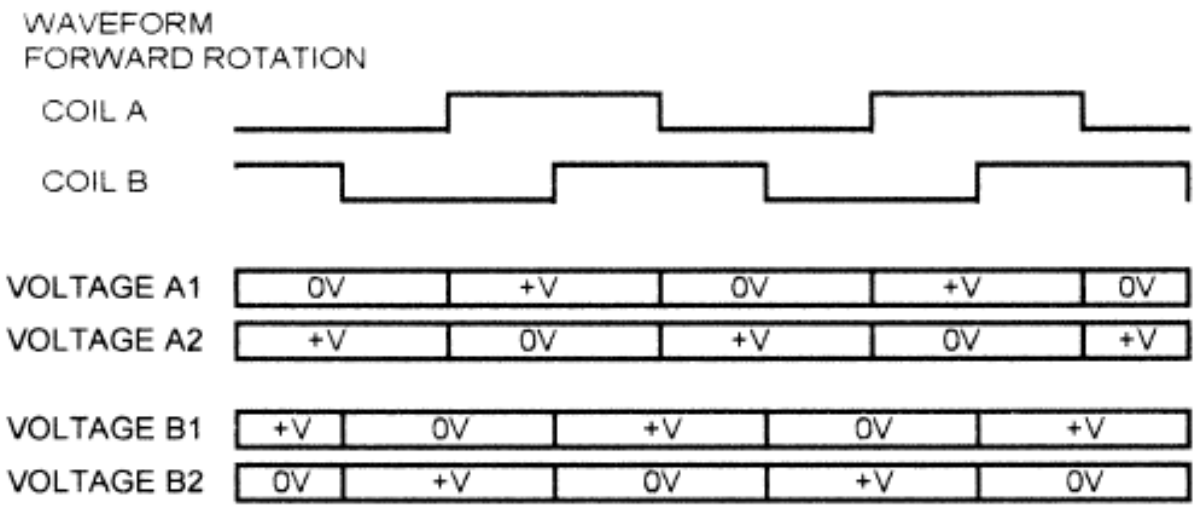
- Put a current-limiting resistor in series with LED and connect it between positive supply and ground

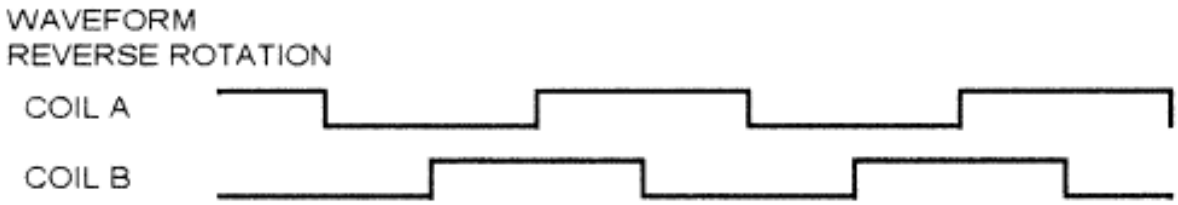


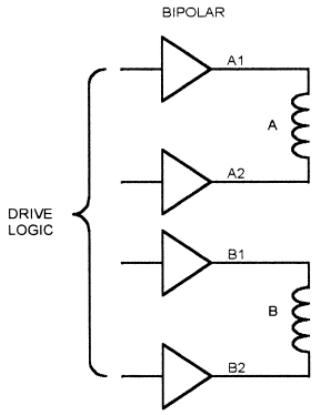


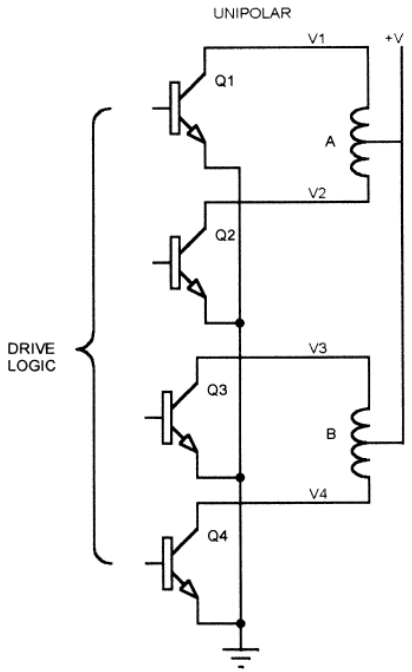


Stepper Motors



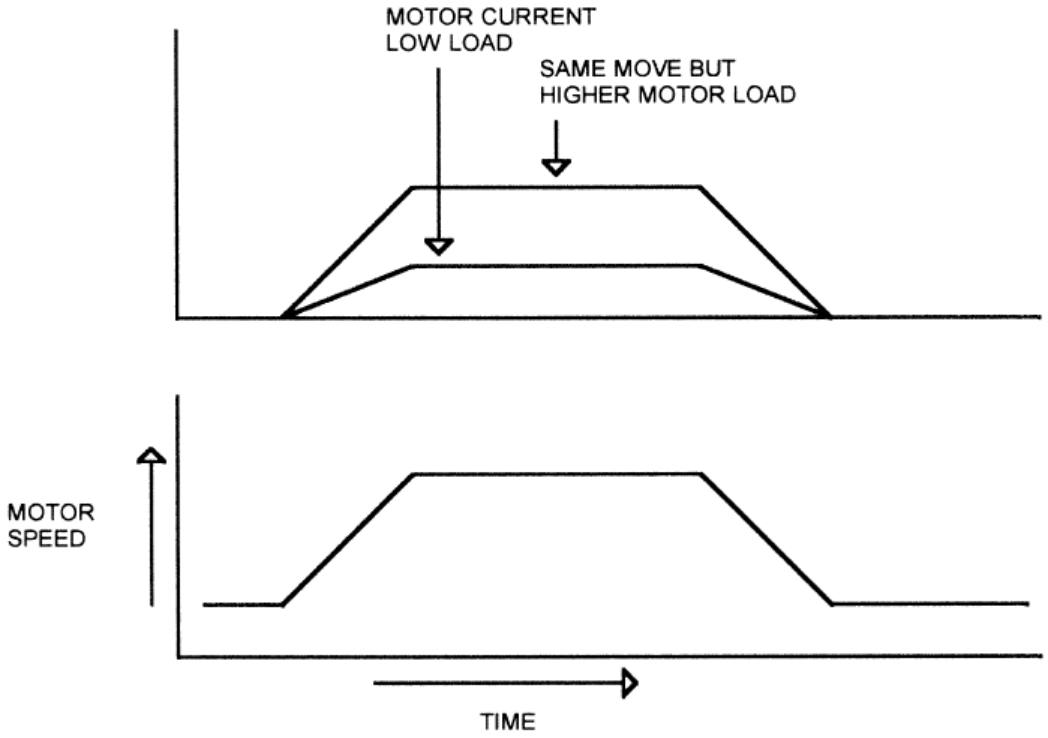






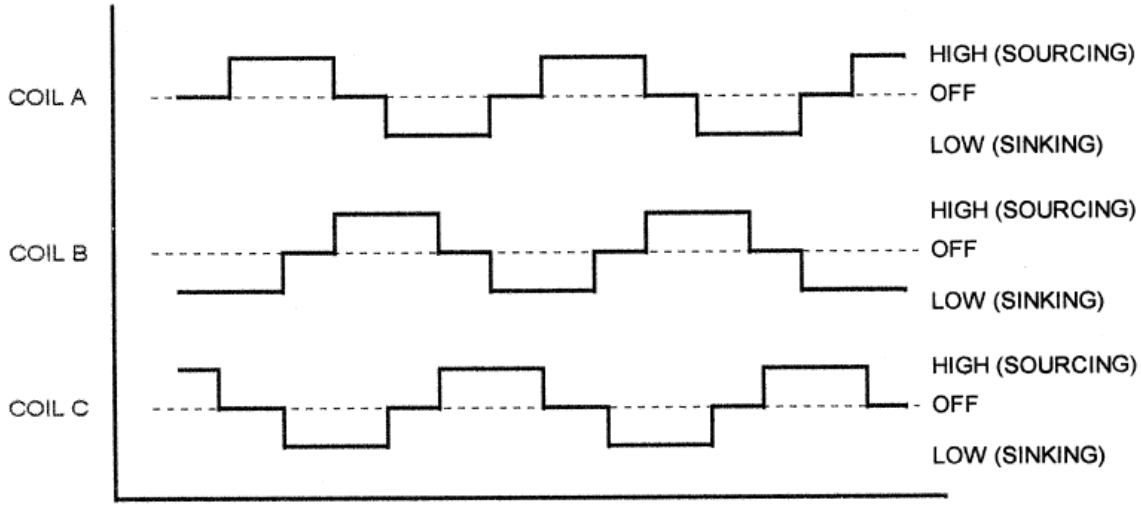
DC Motors

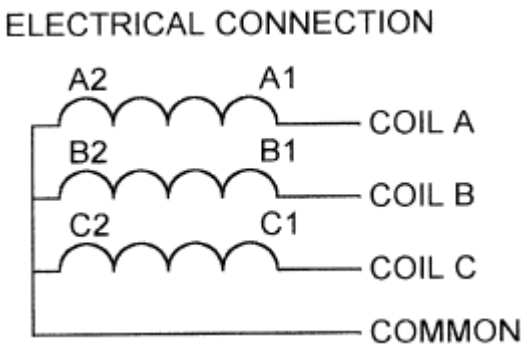
- DC motors are better for applications with large load variations
- *Dynamic Braking:* If you short the motor terminals while motor is running, it quickly comes to a halt



Brushless DC Motors

- Works much like stepper motor
- More efficient than a brushed DC motor





Trade-Off Between Motors

- Stepper motors require no encoder and no feedback system to determine motor position. Position of shaft is determined by the controller, which produces step pulses to the motor.
  - This can also be a disadvantage. If the load is too high, the stepper may stall and there is no feedback to report that condition to the controller. A system using a DC motor with an encoder can tell when this condition occurs.
- A stepper can produce full torque at standstill, if the windings are energized. This can provide the ability to hold the rotor in a specific position.
- A stepper can produce very low rotation speed with no loss of torque. A DC motor loses torque at very low speeds because of lower current

Trade-Off Between Motors

- Steppers have no brushes, so they produce less EMI.
- DC motors deliver more torque at higher speeds than an equivalent stepper.
- Because there is no feedback, a stepper-based system has no means to compensate for mechanical backlash.
- Brushless DC motors require electronic commutation, which is more complex than the drive required for brushed DC motors. However, the availability of driver ICs for brushless DC motors makes this less of a concern

Assignments

- Work on your projects !!!