1) Charge Controllers

a. Review of Pb-acid battery charging scheme
   → The charge phase is determined by measuring the battery voltage
   ① "Initial Boost Charge" → uses all available current 
      → done to close to 100% "State of Charge (SOC)"
      → up to ~14.4V
   ② "Absorption Charge" → at constant voltage and low current
      → up to ~14.4V ? decreasing current
   ③ "Float charge" → to keep battery gently topped off
      → up to ~14.0V (Trickle charger)
   ④ "Equalization Charge" → for flooded (wet) 12V Pb-acid battery
      → gassing stirs up electrolyte and prevents acid stratification
      → up to 14.7V

b. Purpose of the Charge Controller

① Protects battery from overcharging when PV energy supply exceeds load energy demand
② Protects battery from over-discharging when load energy demand exceeds PV energy supply
③ Other system control functions, such as occasional equalization charging of flooded batteries
④ System operation display/logging functions
c. Charge Controller Challenges

1. Determining SOC
   - Cannot do this by just measuring voltage
   - SOC depends on history too
     - ex: Run the battery for a while and the voltage drops. Disconnect it and the battery voltage will slowly recover without recharging
     - ex: Charge the battery and the voltage rises. Cease charging and the battery voltage will slowly fall back to a lower voltage
   - i.e., the charge controller must record battery history and make use of this information

2. Hysteresis
   - want to minimize charging/use hysteresis
     - ex: Charge battery until voltages reaches a max value. Disconnect battery to prevent overcharging
     - Without load, battery voltage starts to drop. How low do you let the battery voltage drop before you begin charging?
     - ex: Disconnect load when battery voltage gets too low. Without recharging, battery voltage slowly increases. When do you reconnect the load?
   - Desire to minimize this hysteresis without under or overcharging or overdischarging the battery
d. Charge Controller Topologies

- Simple charge controller
  - up to maybe 100 W
  - use with 12 V battery
  - 6 terminals: PV (2), Battery (2), Load (2)
  - low cost
  - PV home use
  - Show Fig 5.5

- Fuse protects in the case where the battery gets shorted
Figure 5.5 A simple scheme for a low-power solar home system (SHS).