AMERICAN RIVER COLLEGE

Voltage Drop

Lesson Plan

- Conductors, PV, and NEC
  - Voltage drop

Voltage Drop Calculation

- Voltage drop is NOT an NEC code issue
  - It is not a safety issue
  - Still important design consideration ($$$$)
  - Power = I * V, as V drops, P drops
- Ohms Law
  - V = I * R
  - ΔV = I * R where I = amperage in conductor,
    R = property of the conductor
- Conductor resistance
  - Decreases as conductor size increases
  - Increases as conductor temperature increases

Voltage Drop Calculation

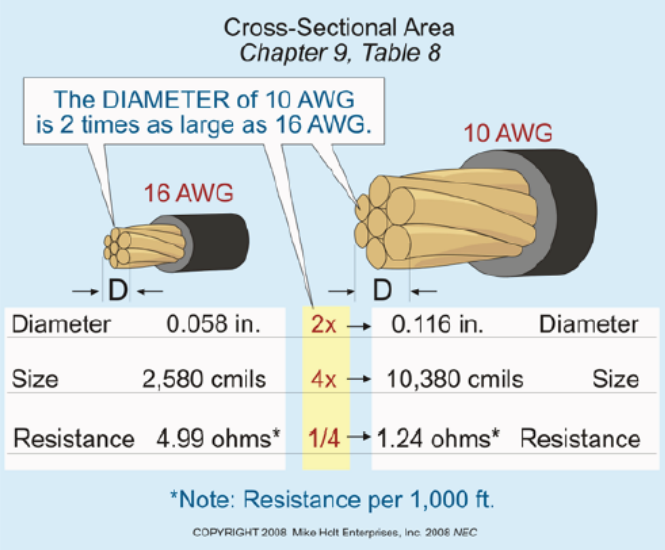
- NEC Chapter 9, Table 8 – Conductor properties
  - Direct Current Resistance at 75C
  - Stranded versus solid conductors
  - Copper versus Aluminum
  - Size 18 to 4/0
  - Area, diameter, and Ohm/kFT / Ohm/km

Table 8–1. Conductor Properties, *NEC* Chapter 9, Table 8

Conductor Size American Wire Gage	Conductor Resistance Per 1,000 Feet at 75°C	Conductor Diameter Inches	Conductor Area Circular Mils
14 AWG	3.140 ohms (stranded)	0.073	4,110
12 AWG	1.980 ohms (stranded)	0.092	6,530
10 AWG	1.240 ohms (stranded)	0.116	10,380
8 AWG	0.778 ohms (stranded)	0.146	16,510
6 AWG	0.491 ohms (stranded)	0.184	26,240

Voltage Drop Calculation

- Resistance as a function of diameter
  - How does resistance change if diameter is doubled?



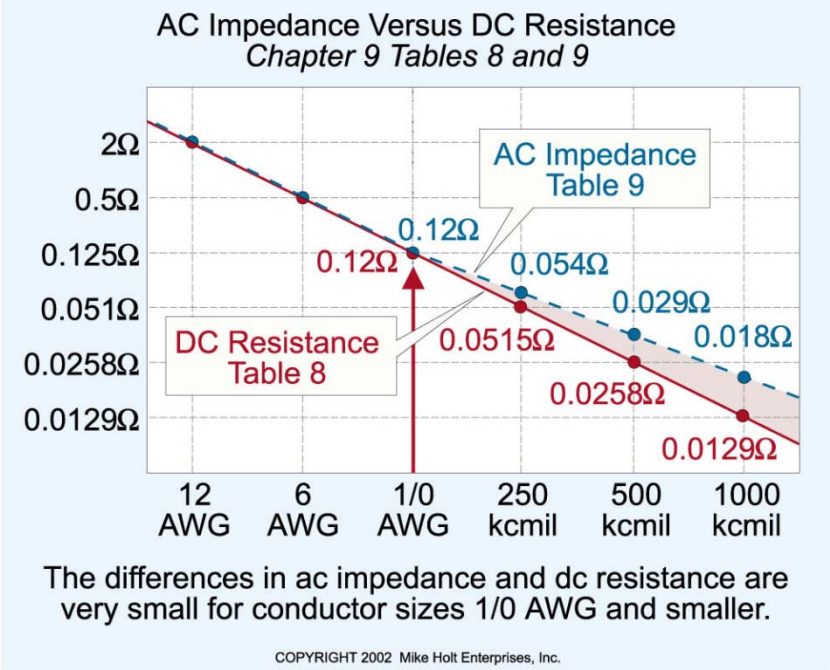
- Resistance as a function of temperature
  - How does resistance change if temp = 150C?

Temperature Adjustment, Table 8, Note 2:

R for CU = Table R x [1 + (0.00323 x (Temp°C - 75°))]
R for AL = Table R x [1 + (0.00333 x (Temp°C - 75°))]

Voltage Drop Calculation

- What about Alternating Current Resistance?
  - NEC Chapter 9, Table 9
  - More complex considerations
  - Power factor, and effective impedance
  - DC table is fairly accurate for conductors smaller than 2AWG



Voltage Drop Calculation

- Calculate resistance in conductors

  (Uncoated is used, it does not mean uninsulated)

  – What is the resistance in 200ft of 12AWG copper stranded at 30C?

  1.98 Ohm/kFT * 200/1000 = 0.396 Ohm

  – What is the resistance of 400ft of 10AWG copper stranded at 100C?

  1.24 Ohm/kFT * 400/1000 * (1+ 0.00323 * (Temp – 75C)) = 0.536 Ohm

  – What is resistance in circuit between junction box and inverter if distance between them is 300ft and we are using 10AWG copper stranded at 50C?

  1.24 Ohm/kFT * 600/1000 = 0.744 Ohm

Voltage Drop Calculation

- What is an acceptable voltage drop?
  - No code requirements
  - Typically measured as a percentage of the nominal voltage
  - 5% or greater bad
  - 2% - 3% is considered “good: design practice
  - What is the voltage drop in 200ft of 12AWG copper stranded at 30C if amperage is 4A?

    4A * 0.396 Ohm = 1.58V
  - If circuit voltage is 12V, what is the percent voltage drop?

    1.58V / 12V = 13.2%
  - If circuit voltage is 48V, what is the percentage drop?

    1.58V / 48V = 3.3%

Voltage Drop Calculation

- What amperage do we use in PV voltage drop calcs?
  - The higher the amperage, the greater the calculated drop
  - Rule of thumb:
    - Use Peak Power amperage (IMP) for grid-tied PV currents
    - Use ISC for battery charging circuits PV circuits
    - Use max steady state current of the load
    - Use max steady state current for battery to inverter circuits
- What voltage do we use in PV voltage drop calcs?
  - Doesn't matter if we are trying to measure the actual voltage loss
    - Example calculating voltage drop to make sure on/off set point is not reached
  - Use nominal percentage if you are looking for percentage

Voltage Drop Calculation

Example 4 (breakout into groups and try): (RT=Round Trip)

(Distance must be multiplied by 2 unless round trip is stated.)

- Determine voltage drop in grid-tied PV source circuit
  (12AWG stranded, 200FT RT, ISC = 5.2A IMP = 4.95, Temp = 40C)

1.98 Ohm/kFT * 200/1000 * 4.95A = 1.96V

- Determine voltage drop in battery charging circuit
  (2AWG, 50FT RT, ISC = 41.6A IMP = 39.6A, Temp = 120C)

0.194 Ohm/kFT * 50/1000 * 41.6A*(1 + 0.00323*(120C-75C)) = 0.46V

- Is this acceptable for a 12V system with 2%-3% voltage drop?

0.46V / 12V = .03833 * 100 = 3.8%, NO