PROBLEM 3 – APPLICATIONS

The mean time between failures for a transformer is 11,000 years. What is most nearly the probability that the transformer will last 30 years?

$$P = e^{-\lambda t}$$

$$P = reliability\ over\ period\ t;\ \lambda = failure\ rate; t = time\ period$$

(A) 99.0%

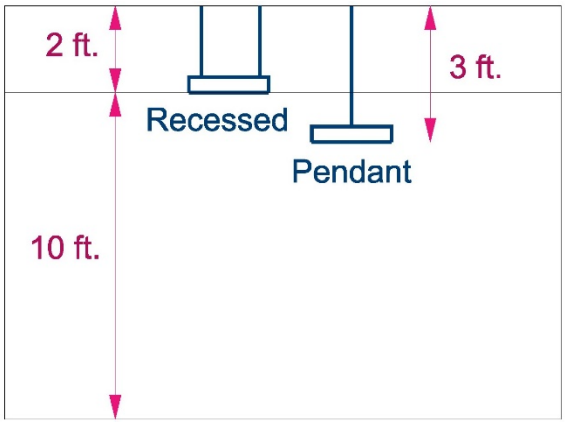
(B) 99.3%

(C) 99.7%

(D) 99.9%

PROBLEM 4 – APPLICATIONS

A conference room is 20 feet by 40 feet. It has a floor to ceiling height of 10 feet. The plenum above the ceiling is 2 feet. The design table height is 2 feet 6 inches. If recessed lights are switched to pendant lights, then what will be the change in the room cavity ratio and will this tend to increase or decrease the coefficient of utilization?



(A) Room cavity ratio is decreased by 0.37, which will increase the coefficient of utilization.

(B) Room cavity ratio is decreased by 0.37, which will not change the coefficient of utilization.

(C) Room cavity ratio is decreased by 2.44, which will decrease the coefficient of utilization.

(D) Room cavity ratio is increased by 2.44, which will not change the coefficient of utilization.

PROBLEM 15 – TRANSMISSION AND DISTRIBUTION

A 3 phase, 50 mile long transmission line system requires a phase voltage of $200\angle 0°$ KV at the end of the system. The transmission line reactance is 5 ohms per mile. The system transmits 100 MVA at a lagging power factor 0.85. This is the power available at the receiving end. What is the voltage at the beginning of the transmission line?

(A) $200\angle 30° \; KV$

(B) $225\angle 9° \; KV$

(C) $312\angle 20° \; KV$

(D) $330\angle 5° \; KV$

PROBLEM 16 – TRANSMISSION AND DISTRIBUTION

Harmonics occur on the secondary side of a delta primary and a wye-grounded (4-wire) secondary transformer. Which of the following is true about triplen harmonics?

(A) Triplen harmonics will not flow on both line sides of the transformer.

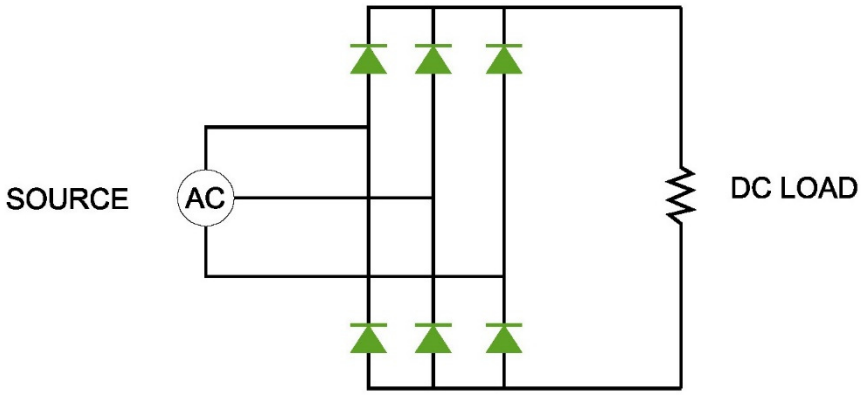
(B) Triplen harmonics will not flow on primary line side of the transformer, but will flow on the secondary line side of the transformer.

(C) Triplen harmonics will not flow on secondary line side of the transformer, but will flow on the primary line side of the transformer.

(D) Triplen harmonics will flow on both line sides of the transformer.

PROBLEM 26 – DEVICES AND POWER ELECTRONIC CIRCUITS

A three phase,full wave rectifer is used to serve a 400 V DC load. The input to the rectifier is 480 V (maximum), 3 PH, 60 HZ. At what firing angle delay, will the output of the rectifier equal the load voltage? Assume any resistance through the rectifier is negligible.



(A) 8 degrees

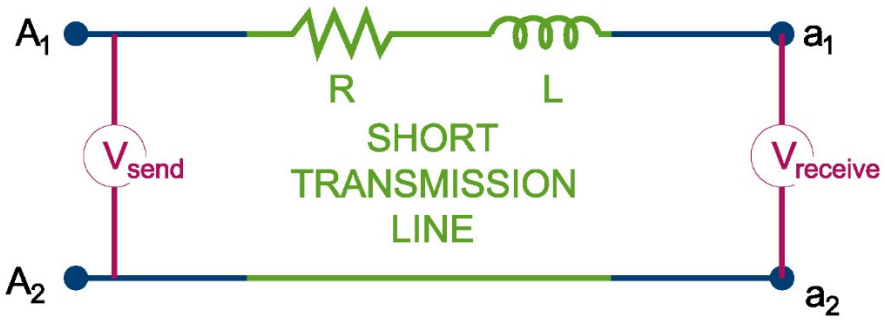
(B) 27 degrees

(C) 40 degrees

(D) 52 degrees

PROBLEM 36 – TRANSMISSION AND DISTRIBUTION

The sending voltage is 22∠10° kV and the receiving voltage is 19.9∠0° kV. The resistance is 18 ohms and the reactance is equal to 10 ohms. What is the magnitude of the 3-PH reactive power at the receiving end? The voltages provided are phase voltages.



(A) 2.0 MVAR

(B) 4.1 MVAR

(C) 7.2 MVAR

(D) 12.9 MVAR

PROBLEM 40 – CODES AND STANDARDS

66kV overhead supply cables are installed near a traffic light pole. The conductors are located above a pedestrian walkway. What is the most nearly the minimum horizontal clearance requirement between the supply cables and the traffic light pole per NESC?

(A) 3.5 ft

(B) 6.5 ft

(C) 11.5 ft

(D) 13.0 ft

PROBLEM 57 – CODES AND STANDARDS

A conductor feeds a 208V, 3 phase, 5 hp non-continuous duty motor, a 208V, 3 phase, 15 hp continuous duty motor and a 208V, 5 amp continuous duty load. The copper conductor is insulated, type THWN, installed in 105°F ambient conditions. What is the minimum allowable conductor size based on NEC 2017? Assume located in a raceway. All motors are induction, squirrel cage type. Also assume the minimum temperature rating of any connected terminal, device or conductor is 75 °C.

(A) 8 AWG

(B) 6 AWG

(C) 4 AWG

(D) 3 AWG

PROBLEM 58 – CODES AND STANDARDS

A 460 V, 3ph, 10 hp, TEFC, continuous duty motor has a 1.1 service factor, a 0.8 PF, a 12.5 FLA nameplate rating, and a 50°C temperature rise. Which of the following is true, based on NEC 2017?

(A) A thermal protection device may be set to protect the motor at 20 A.

(B) The overload device may be set to protect the motor at 15 A.

(C) An instantaneous trip breaker may not be installed at 50 A

(D) No overload protection is required, only branch circuit short circuit and ground fault protection.

PROBLEM 74 – TRANSMISSION AND DISTRIBUTION

Which of the following methods is NOT always used to increase a power system's stability?

(A) Increase internal voltage of generators.

(B) Decrease impedance of the transmission/distribution system.

(C) Increase angle between mechanical angle between generators' rotor and stator fields.

(D) Increase generator excitation current.

PROBLEM 75 – TRANSMISSION AND DISTRIBUTION

A transmission line has a reactance of 60 ohms. The sending voltage is at 200 kV (phase voltage) and the receiving voltage is at 200 kV (phase voltage). The sending voltage leads the receiving voltage by 20 degrees. What reactive power is consumed by the transmission line?

(A) 219 MVAR

(B) 241 MVAR

(C) 368 MVAR

(D) 491 MVAR

PROBLEM 80 – CODES AND STANDARDS

Conductors are tapped from 600 kcmil feeders to power a 75 hp, 460V, 3ph, 60 Hz, continuous duty, wound rotor motor. The feeder and feeder taps are type THHN rated for 90°C. The feeder taps are enclosed in a raceway and travels 15 ft in length before reaching the overcurrent protection device. What is the minimum size the feeder taps per NEC 2017?

(A) 3 AWG

(B) 2 AWG

(C) 1 AWG

(D) 1/0 AWG

A battery has a C/20 rating of 200 amp-hours. If the voltage drop through the resistor at this rating is 0.2 V, what is the internal resistance of the battery?

The C/20 rating indicates the amount of amp-hours discharged in 20 hours.

$$Current = \frac{200\ amp - hours}{20\ hours} = 10\ amps$$

This is the average amount of current traveling through the battery during this rating. If the voltage drop is 0.2 V, you can use Ohm's law to find the internal resistance of the battery.

$$0.2\ V = 10\ amps * R$$

$$R = 0.02\ \Omega$$

(A) 0.02 ohms

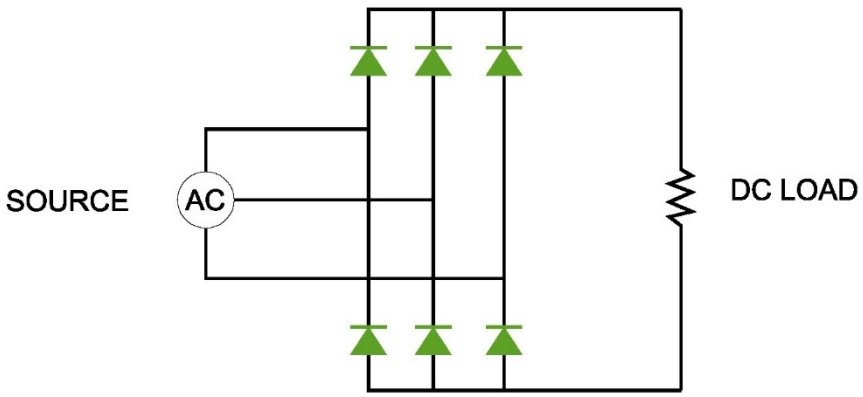
(B) 2 ohms

(C) 5 ohms

(D) 10 ohms

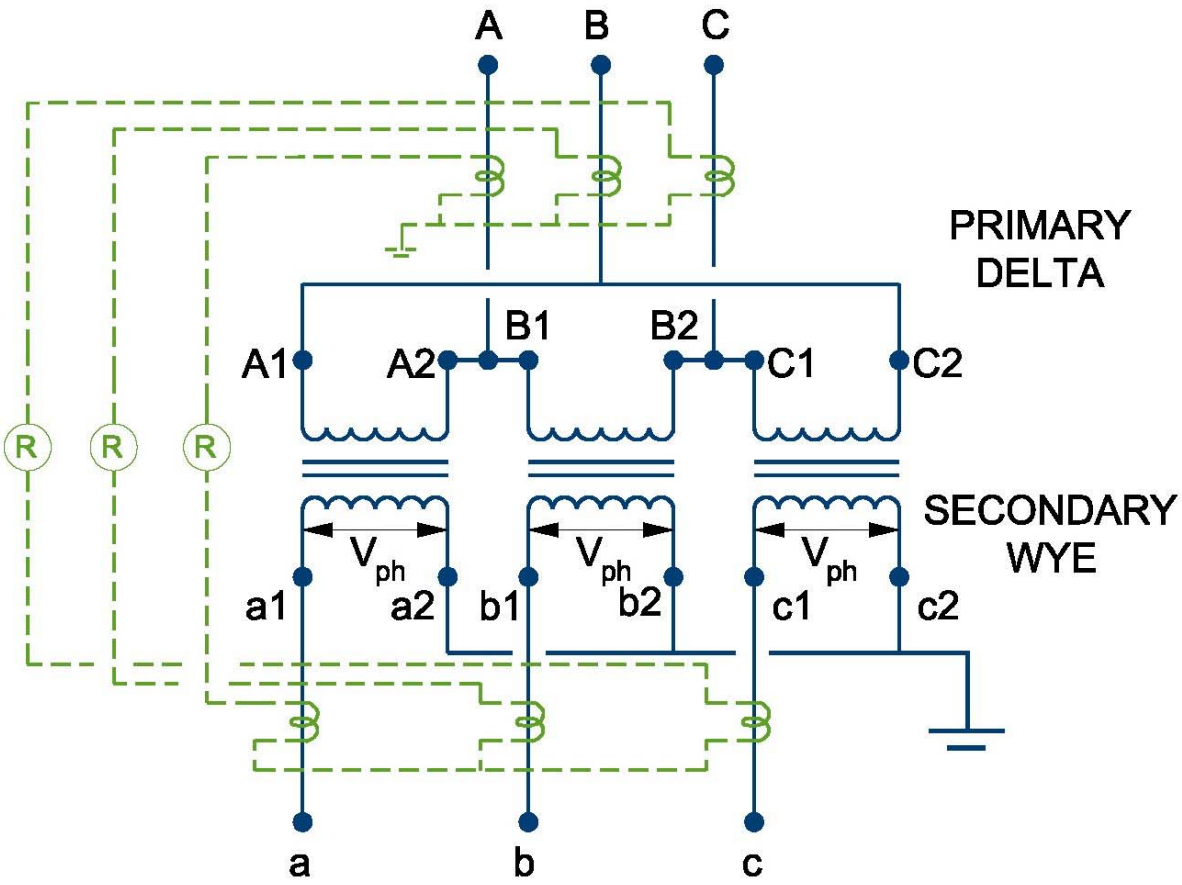
SOLUTION 26 – DEVICES AND POWER ELECTRONIC CIRCUITS

A three phase,full wave rectifer is used to serve a 400 V DC load. The input to the rectifier is 480 V (maximum), 3 PH, 60 HZ. At what firing angle delay, will the output of the rectifier equal the load voltage? Assume any resistance through the rectifier is negligible.



SOLUTION 33 – PROTECTION

A differential protection scheme is shown for the delta-wye transformer below. How would you correct the protection scheme to limit false trips during normal operation? Assume the turns ratio for the transformer is 1:1.



The correct answer is most nearly, (B) The relays on the wye side should follow a delta arrangement. The relays need to be arranged to account for the phase shift and the root 3 factor.

(A) The ground on the primary relays should be removed.

(B) The relays on the wye side should follow a delta arrangement.

(C) A ground should be added on the secondary relay arrangement.

(D) No change is required.

The equation to find the output of a full wave rectifier is shown below for an uncontrolled rectifier from the NCEES Power PE Reference Handbook.

$$V_{DC} = \frac{1}{\pi/3}\int_{60}^{120} V_{line,AC} * \sin(\theta)$$

However, we need to control this rectifier, so we will exchange the top part of the integral to the delay angle.

$$V_{DC} = 400\ V = \frac{1}{\pi/3}\int_{\theta}^{120} V_{line,AC} * \sin(\theta) \rightarrow \frac{V_{line,AC}}{\frac{\pi}{3}}(-\cos(120) + \cos(\theta))$$

$$400\ V = \frac{V_{line,AC}}{\frac{\pi}{3}}(0.5 + \cos(\theta))$$

$$400\ V = \frac{480\ V}{\frac{\pi}{3}}(0.5 + \cos(\theta))$$

$$\cos(\theta) = 0.373$$

$$\theta = 68.12°$$

The delay angle is the delay from 60 degrees.

$$Delay\ angle = 68.12° - 60° = 8.12°$$

The correct answer is most nearly, (A) 8 degrees.

(A) 8 degrees

(B) 27 degrees

(C) 40 degrees

(D) 52 degrees

SOLUTION 27 – ROTATING MACHINES

A variable frequency drive varies the frequency and voltage to an induction motor, in accordance with the graph below. Which of the following statements is most likely true as the frequency is reduced from 60 HZ to 45 HZ.

Then solve for the power on the receiving side.

$$S = I^* * V * 3 = (204.4\angle -36.1°) * (19{,}900\angle 0°) * 3$$

$$S = 12{,}202{,}680\angle -36.1°$$

Now solve for the reactive power.

$$Q = 12{,}202{,}680 * \sin(-36.1°) = 7{,}189{,}775\ VAR = -7.2\ MVAR$$

The negative reactive power indicates that the receiving end is a supplier of reactive power. The reactive power is flowing from the receiving end to the sending end. But the magnitude is still 7.2 MVAR.

The correct answer is most nearly, (C) 7.2 MVAR.

(A) 2.0 MVAR

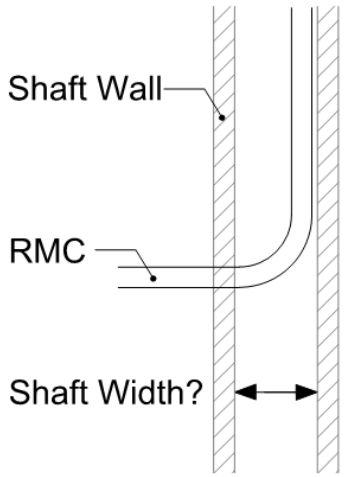
(B) 4.1 MVAR

(C) 7.2 MVAR

(D) 12.9 MVAR

SOLUTION 37 – CODES AND STANDARDS

Twelve 500 kcmil THHW wires are installed in a single rigid metal conduit. The conduit enters a shaft horizontally and makes a 90 degree bend up within the shaft as shown below. The conduit is installed per NEC 2017 with a one shot bend. What is most nearly the minimum shaft width required? Assume a conduit wall thickness of 0.25".



Based on NEC 2017, Table C.9, a maximum of fourteen 500 kcmil THHW wires are allowed in a trade size 6 RMC and ten wires are allowed in a trade size 5 RMC. Therefore, the RMC will be

234B1 says horizontal clearance for lines up to 22kV for conductors passing near traffic signal support is 5 ft

234G1 says that for voltages 22-470kV the clearances in 234B should be increased by 0.4 in/kV in excess of 22 kV

234G2 says that for voltages over 50kV the additional clearance provided in 234G1 should be increased by 3% per 1000 ft above 3300 ft

We don't know elevation, so minimum clearance is 5ft + (66kV-22kV) * 0.4 in/kV = 6.5 ft

234B is specifically used for traffic signal poles.

234C seems to be used for structures that don't have power.

234B seems to be used for structures that do have power.

The answer is (B) 6.5ft.

(A) 3.5 ft

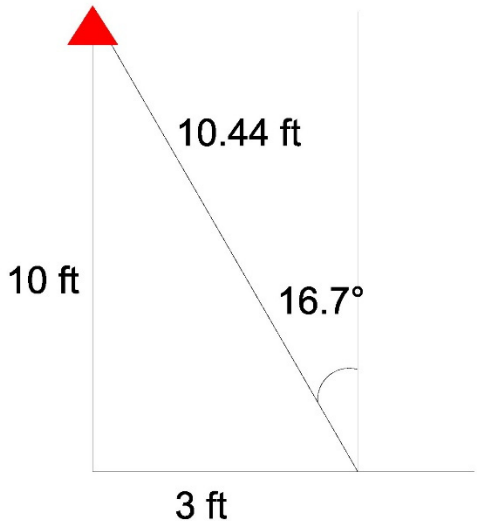
(B) 6.5 ft

(C) 11.5 ft

(D) 13.0 ft

SOLUTION 44 – APPLICATIONS

A light is located 10 feet above a walkway. The center of the walkway is located a horizontal distance of 3' from the light. What is the foot candles at the center of the walkway? Assume the light produces 1,000 candela.



$$FC = \frac{I * \cos(\theta)}{d^2}$$

$$FC = \frac{1{,}000 * \cos(16.7°)}{10.44^2} = 8.8\ fc$$

The correct answer is most nearly, (A) 8.8 fc.

(A) 8.8 fc

(B) 9.3 fc

(C) 10.1 fc

(D) 11.9 fc

SOLUTION 57 – CODES AND STANDARDS

A conductor feeds a 208V, 3 phase, 5 hp non-continuous duty motor, a 208V, 3 phase, 15 hp continuous duty motor and a 208V, 5 amp continuous duty load. The conductor is insulated, type THWN, installed in 105°F ambient conditions. What is the minimum allowable conductor size based on NEC 2017? Assume located in a raceway. All motors are induction, squirrel cage type. Also assume the minimum temperature rating of any connected terminal, device or conductor is 75 °C.

(A) 8 AWG

(B) 6 AWG

(C) 4 AWG

(D) 3 AWG

$$Conductor\ Amp\ (A) = 125\% * Motor\ FLA_{largest\ motor} + \sum Motor\ FLA_{other\ motors} + 100\% * Non\ Motor\ Amp_{non\ continuous} + 125\% * Non\ Motor\ Amp_{continuous}$$

Find the FLA for the motors from Table 430.250 of the NEC.

$$5\ hp\ motor, 208V/3ph \rightarrow 16.7\ FLA$$

$$15\ hp\ motor, 208V/3ph \rightarrow 46.2\ FLA$$

Solve for the Conductor Amps:

$$Conductor\ Amp\ (A) = 1.25 * 46.2\ FLA + 16.7\ FLA + 1.25 * 5\ FLA = 80.7\ A$$

Since the motor is located in 105°F conditions, find the correction factor from Table 310.15(B)(2)(a), using a 75°C conductor rating and 30°C ambient conditions, as rated in Table 310.15(B)(17).

The correction factor is 0.82.

$$Corrected\ Conductor\ Amp\ (A) = 0.82 * 100A\ (3\ AWG\ wire) = 82A$$

From Table 310.15(B)(16), the minimum THWN conductor size is 3 AWG.

The correct answer is most nearly **(D) 3 AWG**

$$Conductor\ Amp\ (A) = \ 1.25 * 46.2\ FLA + 16.7\ FLA + 1.25 * 5\ FLA = 80.7\ A$$

Since the motor is located in 105°F conditions, find the correction factor from Table 310.15(B)(2)(a), using a 75°C conductor rating and 30°C ambient conditions, as rated in Table 310.15(B)(17).

The correction factor is 0.82.

$$Corrected\ Conductor\ Amp\ (A) = 0.82 * 100A\ (3\ AWG\ wire) = 82A$$

From Table 310.15(B)(16), the minimum THWN conductor size is 3 AWG.

The correct answer is most nearly (D) 3 AWG

(A) 8 AWG

(B) 6 AWG

(C) 4 AWG

(D) 3 AWG

SOLUTION 58 – CODES AND STANDARDS

A 460 V, 3ph, 10 hp, TEFC, continuous duty motor has a 1.1 service factor, a 0.8 PF, a 12.5 FLA nameplate rating, and a 50°C temperature rise. Which of the following is true, based on NEC 2017?

The correct answer is (A).

Based on NEC 430.32 for continuous duty motors over 1 hp, a thermal protector may be used to protect the motor, but must not be more than 156% of the FLA from Table 430.250. The maximum thermal protection device at 14 FLA * 1.56 is 21.84 A. Therefore, (A) is acceptable.

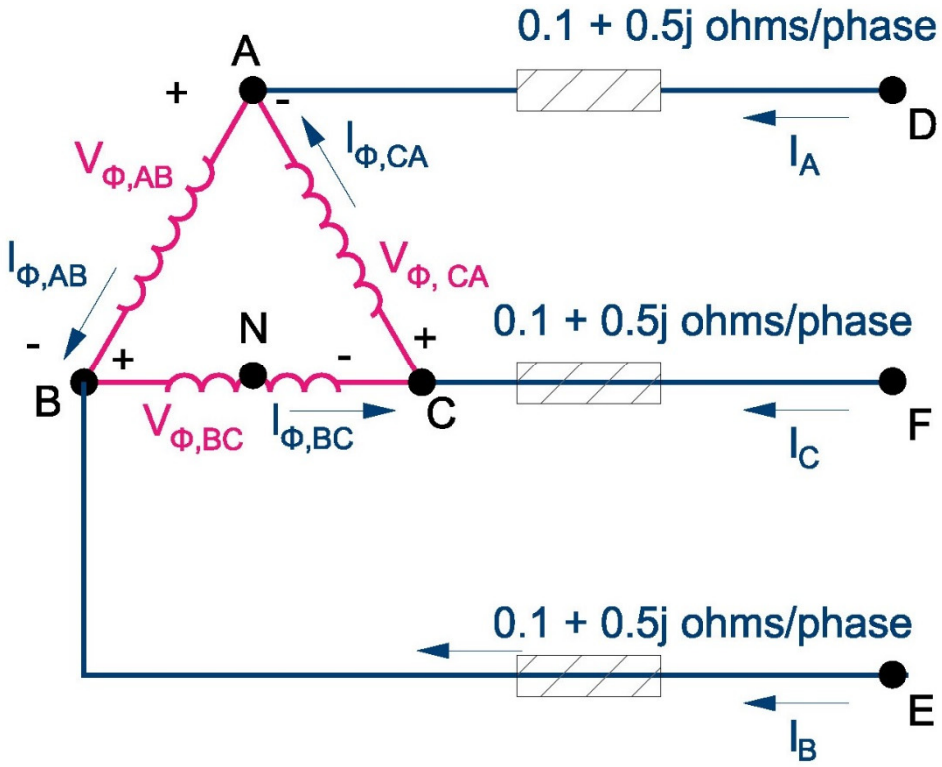
(B) is not true since the overload device cannot be greater than 1.15 times the nameplate rating FLA based on the given service factor and the temperature rise, per 430.32 (A)(1).

(C) is not true. An instantaneous trip breaker must not exceed 800% of the full load current, but can be less. In fact, it should be set as low as possible for optimal protection.

(D) is not true. A separate overload device is required for continuous duty motors. It is not required for intermittent duty motors.

SOLUTION 61 – CIRCUIT ANALYSIS

A 3-phase, 10 KVA, delta-connected, purely resistive load has an I_{AB} phase current of $17.34\angle 30°$ amps. The lines leading to the load have a line impedance of .1 + .5j ohms per phase. Assume a balanced load. What is the voltage between points D & E? A-B-C phase sequence.



First, solve for the voltage drop AB.

$$10{,}000\ VA = 3 * V_{AB} * 17.34\ A\angle -30°$$

$$V_{AB} = 192.2\ A\angle 30°$$

Next, solve for the line currents.

$$I_A = (17.34\ A\angle 30°) * \left(\sqrt{3}\angle -30°\right) = 30.03\angle 0°$$

$$I_B = 30.03\angle -120°;\ I_C = 30.03\angle 120°$$

Now solve for the line voltage, but you know for delta that phase is equal to line.

$$V_{DA} = (30.03\angle 0°) * (0.1 + 0.5j) = 15.3\angle 78.7°$$

$$V_{BE} = -(30.03\angle -120°) * (0.1 + 0.5j) = 15.3\angle 138.69°$$

Add the voltage drops from D to E.

$$5{,}060{,}000\ VA = I * 1{,}200\ V * \sqrt{3}$$

$$I = 2437\ A$$

The correct answer is most nearly, (B) 2,437 A.

(A) 1,980 A

(B) 2,437 A

(C) 4,222 A

(D) 6.093 A

SOLUTION 74 – TRANSMISSION AND DISTRIBUTION

Which of the following methods is NOT always used to increase a power system's stability?

(A) Increase internal voltage of generators.

(B) Decrease impedance of the transmission/distribution system.

(C) Increase angle between mechanical angle between generators' rotor and stator fields.

(D) Increase generator excitation current.

The correct answer is most nearly, (C) Increase angle between mechanical angle between generators' rotor and stator fields. If you increase the angle to a value greater than 90 degrees, then you can actually create an unstable condition.

SOLUTION 75 – TRANSMISSION AND DISTRIBUTION

A transmission line has a reactance of 60 ohms. The sending voltage is at 200 kV (phase voltage) and the receiving voltage is at 200 kV (phase voltage). The sending voltage leads the receiving voltage by 20 degrees. What reactive power is consumed by the transmission line?

First solve for current.

The correct answer is most nearly, (B) 0.17 Ω

(A) 0.056 Ω

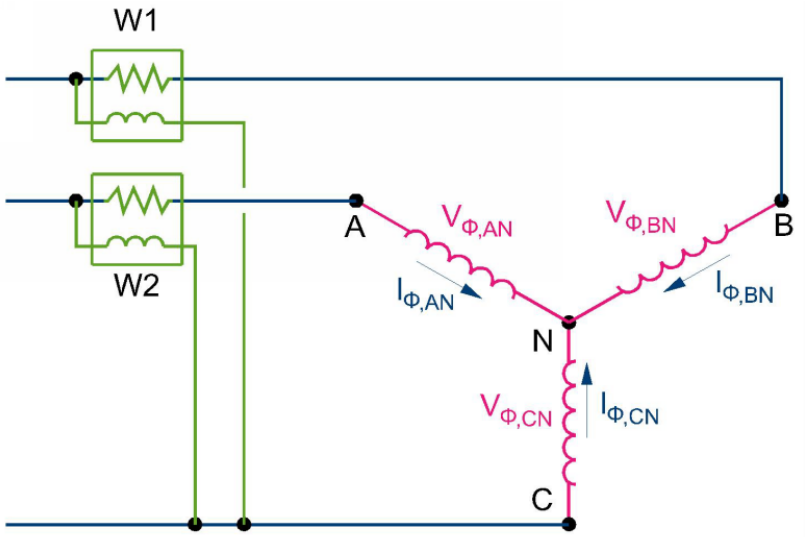
(B) 0.17 Ω

(C) 0.35 Ω

(D) 1.1 Ω

SOLUTION 79 – MEASUREMENT AND INSTRUMENTATION

Current transformers and potential transformers are arranged to produce wattmeters W1 and W2 to measure the power at the load. The wattmeters are configured as shown in below on a 3 wire, balanced wye load with no neutral. The system has a voltage of 208V. The current to the load is 25 A. The load has a power factor of 0.85. What is the total power of the load?



First find the power factor angle.

$$\theta = \cos^{-1}(0.85) = 31.8\,°$$

Fiind the real power at each wattmeter.

$$W_1 = V_{BC} * I_B * \cos(30° + \theta_1) = 208\,V * 12\,A * \cos(30° + 31.8°)$$

$$W_2 = V_{AC} * I_A * \cos(30° - \theta_2)$$

Solve for W1 and W2.

$$W_1 = 208\,V * 25\,A * \cos(30° + 31.8°) = 2458\,W$$

$$W_2 = 208\,V * 25\,A * \cos(30° - 31.8°) = 5197\,W$$

Solve for the total power.

$$P = W_1 + W_2 = 2458\,W + 5197\,W = 7655\,W$$

The correct answer is most nearly, (A) 7600 W.

(A) 7600 W

(B) 8800 W

(C) 9200 W

(D) 10400 W

SOLUTION 80 – CODES AND STANDARDS

Conductors are tapped from 600 kcmil feeders to power a 75 hp, 460V, 3ph, 60 Hz wound rotor motor. The feeder and feeder taps are type THHN rated for 90°C. The feeder taps are enclosed in a raceway and travels 15 ft in length before reaching the overcurrent protection device. What is the minimum size the feeder taps per NEC 2017?

Navigate to NEC 430.28. If the feeder taps are larger than 10 ft, but less than 25 ft before reaching the OCP device, then paragraph (2) applies. The tap feeder must be at least 1/3 of the feeder conductor and at least the size to accommodate the motor.

Find the feeder rating from Table 310.15(B)(16). The feeder conductor ampacity for THHN rated for 90°C at 600 kcmil is 475A.

$$Tap\ Feeder\ (> 10ft\ and\ \leq 25ft) = \frac{1}{3}(475A) = 158A$$

Find the motor FLA requirement from Table 430.250 is 96 A. The conductor to the motor must be at least 125% of this FLA rating.

$$Motor\ Branch\ Conductor = 1.25 * FLA = 1.25 * 96A = 120A$$