PRACTICE EXAM 6: PE POWER SIMULATION (80 QUESTIONS)

1. A 13.8 kV, three-phase feeder supplies a balanced load of 6,000 kVA at 0.82 lagging power factor. The feeder impedance is 0.60 + j2.80 Ω per phase. What is the approximate percent voltage drop on the feeder?

A. 2.1%

B. 8.6%

C. 5.3%

D. 3.7%

2. A CT with a ratio of 2000:5 has a C800 accuracy class. A relay with a burden of 4.0 Ω is connected through secondary leads with a total resistance of 2.5 Ω. The CT winding resistance is 1.5 Ω. At 20 times rated secondary current, is the total burden within the CT's accuracy rating?

A. No, the total burden of 8.0 Ω produces 800V, which equals the C800 limit exactly with no margin

B. Yes, the total burden of 8.0 Ω produces 800V, which is at the C800 maximum rating

C. No, the total burden exceeds the C800 capability because only external burden counts

D. Yes, because C800 means the CT is accurate up to 800 times rated current

3. A 50 MVA, 138/69 kV autotransformer has a series impedance of 9% on its own base. On a 100 MVA system base with V_base = 138 kV on the high side, what is the transformer's per-unit impedance?

A. 0.09 pu

B. 0.45 pu

C. 0.045 pu

D. 0.18 pu

4. Per NEC 430.22, the minimum branch-circuit conductor ampacity for a single motor must be at least 125% of the motor FLA from the applicable NEC table. A 75 HP, 460V, three-phase motor has a Table 430.250 FLA of 96A. What is the minimum conductor ampacity required, and what is the minimum copper conductor size at 75°C?

A. 120A minimum; 1 AWG copper (ampacity 130A at 75°C)

B. 96A minimum; 3 AWG copper (ampacity 100A at 75°C)

C. 115A minimum; 2 AWG copper (ampacity 115A at 75°C)

D. 144A minimum; 1/0 AWG copper (ampacity 150A at 75°C)

5. A 480V, three-phase, 60 Hz power system feeds a 200 HP induction motor through a VFD. The VFD has a 6-pulse diode rectifier front end. The total input current THD is 28%. The facility's I_SC/I_L ratio at the point of common coupling is 35. Per IEEE 519 Table 2, the maximum allowable total demand distortion (TDD) for this ratio is 8%. Is the VFD installation compliant with IEEE 519?

A. Yes, because TDD only considers individual harmonics, not total distortion

B. No, the measured THD of 28% exceeds the 8% TDD limit by a factor of 3.5

C. Yes, because the 28% THD at the VFD terminals will be lower at the PCC

D. No, and the installation requires immediate shutdown until mitigation is installed

6. A balanced three-phase, wye-connected source has a line-to-line voltage of 4,160V. A delta-connected capacitor bank rated 2,400 kvar is installed on the bus. What is the line current drawn by the capacitor bank?

A. 166.6 A

B. 288.7 A

C. 96.2 A

D. 333.2 A

7. Per NEC Article 700.12, emergency systems must have a minimum of two independent sources of power: a normal source and an alternate source. When a generator serves as the alternate source, it must be equipped with what type of fuel transfer capability?

A. An on-site fuel supply with automatic fuel transfer to the generator day tank

B. A manual fuel transfer system with a gravity-feed backup

C. A connection to the municipal natural gas supply as primary fuel

D. Dual fuel capability (diesel and natural gas) for redundancy

8. A three-phase, 480V system has the following per-unit sequence impedances at a fault bus: $Z_1 = 0.015 + j0.04$ pu, $Z_2 = 0.015 + j0.04$ pu, $Z_0 = 0.03 + j0.10$ pu on a 2,000 kVA base. What is the bolted three-phase fault current in amperes?

A. 1,203 A

B. 28,100 A

C. 56,200 A

D. 14,050 A

9. A 4,160V, three-phase, 8-pole synchronous motor drives a ball mill at constant speed. The motor nameplate lists a power factor of 0.80 leading at rated load. If the mechanical load is reduced to 50% while the field current remains unchanged, what happens to the motor's power factor?

A. The power factor moves closer to unity because the reactive component becomes dominant

B. The power factor becomes more leading (lower numerical value) because the real component decreases while the reactive component remains approximately constant

C. The power factor remains at 0.80 leading because field current is unchanged

D. The power factor switches from leading to lagging as the load decreases

10. A lightning risk assessment for a petroleum storage facility calculates N_D = 0.45 strikes/year and N_C = 0.02 strikes/year. The ratio N_D/N_C = 22.5. What does this indicate about the lightning protection requirement?

A. Lightning protection is strongly recommended; N_D far exceeds N_C

B. Lightning protection is recommended but optional at the facility owner's discretion

C. The assessment must be repeated because the ratio exceeds 20

D. Lightning protection is strongly recommended; the ratio exceeds 10 and immediate installation is advised

11. A per-unit system uses a 100 MVA base. The base voltage on the high side of a 230/69 kV transformer is 230 kV. What is the base impedance on the 230 kV side?

A. 529 Ω

B. 47.6 Ω

C. 230 Ω

D. 100 Ω

12. A 2,500 kVA, 13.8 kV/480V, delta-wye grounded transformer has an impedance of 5.75% with R_eq = 1.2% and X_eq = 5.62%. At full load with 0.90 lagging power factor, what is the voltage regulation?

A. 1.08%

B. 5.75%

C. 3.52%

D. 6.87%

13. Per NFPA 70E, a qualified person is defined as one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved. An unqualified person approaches a 480V panelboard with exposed energized parts. What is the minimum approach distance this person must maintain?

A. The restricted approach boundary from Table 130.4(E)(a)

B. The limited approach boundary from Table 130.4(E)(a)

C. The arc flash boundary calculated per IEEE 1584

D. 10 feet from all energized parts regardless of voltage

14. A 345 kV transmission line has a total positive-sequence impedance of $Z_1 = 4.0 + j50\ \Omega$ and a total zero-sequence impedance of $Z_0 = 12 + j150\ \Omega$. The source behind the line has $Z_{1\_source} = j10\ \Omega$ and $Z_{0\_source} = j15\ \Omega$ (all on the same base). For a bolted SLG fault at the remote end of the line, what is the total positive-sequence impedance in the fault circuit?

A. 4.0 + j50 Ω

B. j10 Ω

C. 12 + j150 Ω

D. 4.0 + j60 Ω

15. Per NEC 250.122(B), when ungrounded conductors are increased in size for voltage drop, the equipment grounding conductor must also be proportionally increased. The increase is calculated based on the ratio of the circular mil areas. If the circuit conductors are increased from 4 AWG (41,740 CM) to 2 AWG (66,360 CM), and the minimum EGC per Table 250.122 is 10 AWG (10,380 CM), what is the minimum required EGC size?

A. 8 AWG (16,510 CM)

B. 10 AWG (10,380 CM) — no increase is required

C. 6 AWG (26,240 CM)

D. 12 AWG (6,530 CM)

16. An arc flash study at a 13.8 kV switchgear bus calculates an incident energy of 52 cal/cm² at the working distance of 36 inches. The protective device clearing time is 0.5 seconds. Per NFPA 70E, what is the required course of action?

A. PPE Category 4 with additional face and head protection must be worn

B. The work can proceed if two qualified persons are present as a safety team

C. An energized electrical work permit must be issued with enhanced PPE beyond Category 4

D. The equipment must be de-energized because the incident energy exceeds 40 cal/cm²

17. A balanced three-phase, wye-connected load has a per-phase impedance of 12 + j16 Ω. The load is connected to a 480V (line-to-line) source. What is the total three-phase reactive power consumed by the load?

A. 6,144 var

B. 3,686 var

C. 4,608 var

D. 9,216 var

18. A 200 HP, 460V, three-phase motor has a nameplate FLA of 242A and a service factor of 1.15. The motor is protected by an electronic overload relay with adjustable current and trip class settings. Per NEC 430.32(A)(1), what is the maximum overload relay trip setting for this motor?

A. 278.3 A (115% of nameplate)

B. 302.5 A (125% of nameplate)

C. 363.0 A (150% of nameplate)

D. 242.0 A (100% of nameplate)

19. A ground resistance test on an industrial facility's grounding system measures 4.8 Ω using the fall-of-potential method. The design specification requires a maximum of 5.0 Ω. However, the test was performed during summer when soil moisture content was high. What concern should the engineer address?

A. Ground resistance increases during dry seasons and may exceed 5.0 Ω when soil moisture decreases

B. The test is invalid because fall-of-potential measurements are inaccurate during wet conditions

C. The 4.8 Ω reading should be multiplied by a correction factor of 2.0 for seasonal variation

D. No concern exists because ground resistance is independent of soil moisture content

20. A three-phase, 4,160V distribution system serves a 3,000 kW load at 0.78 lagging power factor. The utility charges a $3.00/kvar/month penalty for reactive power exceeding a 0.95 power factor threshold. What is the monthly reactive power penalty?

A. $2,418/month

B. $5,700/month

C. $5,013/month

D. $3,600/month

21. A 138 kV circuit breaker is rated for a maximum symmetrical interrupting current of 40 kA. The system X/R ratio at the breaker location is 25. The standard test X/R ratio for the breaker per IEEE C37.04 is 17. Using a simplified derating approach, the breaker's effective interrupting capability must account for the higher asymmetry. What is the approximate peak first-cycle asymmetrical current the breaker must withstand at its rated symmetrical current?

A. 56.6 kA ($\sqrt{2} \times 40$ kA)

B. 80 kA (2×40 kA)

C. 100 kA (2.5×40 kA)

D. 107.2 kA (2.68×40 kA)

22. A 500 kVA, 480V/208Y/120V, three-phase dry-type transformer is installed in a commercial building. The transformer has an open-circuit loss of 1,800 W and a full-load copper loss of 6,200 W. At what loading does maximum efficiency occur, and what is the efficiency at that loading with a 0.85 power factor?

A. 54% load, efficiency = 97.8%

B. 54% load, efficiency = 97.2%

C. 75% load, efficiency = 98.1%

D. 30% load, efficiency = 96.5%

23. Per NEC Article 501.15(A), in a Class I, Division 1 location, a conduit seal must be placed within 18 inches of the enclosure. The seal fitting must be filled with an approved sealing compound. What is the minimum thickness of the sealing compound within the fitting?

A. Not less than the trade size of the conduit and in no case less than 5/8 inch

B. A minimum of 1 inch regardless of conduit trade size

C. Equal to twice the conduit trade size or 1 inch minimum, whichever is greater

D. No minimum thickness is specified if the compound is UL listed

24. A 10 MVA synchronous generator has the following per-unit reactances on its own base: X''_d = 0.15, X'_d = 0.25, X_d = 1.5, X_2 = 0.18, X_0 = 0.07. The generator is solidly grounded. A bolted three-phase fault occurs at the terminals. What are the subtransient, transient, and steady-state fault currents in per-unit?

A. I''_f = 5.56 pu, I'_f = 3.33 pu, $I_{f(ss)}$ = 0.56 pu

B. I''_f = 6.67 pu, I'_f = 4.00 pu, $I_{f(ss)}$ = 1.50 pu

C. I''_f = 6.67 pu, I'_f = 4.00 pu, $I_{f(ss)}$ = 0.667 pu

D. I''_f = 5.56 pu, I'_f = 4.00 pu, $I_{f(ss)}$ = 0.667 pu

25. A 230 kV transmission line is 120 miles long with a characteristic impedance of 380 Ω. What is the surge impedance loading (SIL) of this line?

A. 69.5 MW

B. 604 MW

C. 230 MW

D. 139 MW

26. A three-phase, 480V bus serves two motor loads and a lighting panel. Motor 1: 100 HP (FLA = 124A). Motor 2: 50 HP (FLA = 65A). Lighting panel: 60A continuous. Per NEC 430.24 and 215.2(A)(1), what is the minimum feeder conductor ampacity?

A. 249 A

B. 295 A

C. 324 A

D. 345 A

27. Per NEC 690.7, the maximum system voltage for a PV array is calculated using the lowest expected ambient temperature. A string of 16 modules has V_{oc} = 46.2V per module at STC. The temperature

coefficient of V_oc is −0.28%/°C. The lowest expected ambient temperature is −20°C. What is the maximum system voltage?

A. 833 V

B. 739 V

C. 695 V

D. 908 V

28. A protective relay coordination study reveals that at a fault current of 6,000A, a downstream 100A fuse has a total clearing time of 0.015 seconds and an upstream feeder relay has an operating time of 0.25 seconds. What is the CTI, and does it indicate adequate coordination?

A. CTI = 0.265 seconds, which exceeds the minimum by 65 milliseconds

B. CTI = 0.015 seconds, which is critically insufficient for coordination

C. CTI = 0.25 seconds, which meets the minimum of 0.20 seconds exactly

D. CTI = 0.235 seconds, which exceeds the minimum of 0.20 seconds

29. A 480Y/277V, three-phase, four-wire panelboard serves a balanced mix of single-phase, 277V LED lighting loads. Each phase serves 40 luminaires drawing 1.2A each. The neutral conductor carries what current under balanced conditions, assuming no harmonic content?

A. 144 A (three times the per-phase current)

B. 83.1 A (√3 times the per-phase current)

C. 0 A (balanced loads produce zero neutral current at fundamental frequency)

D. 48 A (same as per-phase current)

30. Per NEC 110.26(A)(3), the minimum headroom for working spaces around electrical equipment rated 600V or less is what value?

A. 6.5 feet or the height of the equipment, whichever is greater

B. 6.0 feet

C. 7.0 feet

D. 8.0 feet

31. A three-phase, 480V, 200A feeder circuit uses 3/0 AWG copper conductors in EMT. NEC Chapter 9 Table 9 lists R = 0.0766 Ω/1000 ft and X = 0.0454 Ω/1000 ft. The feeder length is 350 feet and the load power factor is 0.85 lagging. What is the voltage drop as a percentage of 480V?

A. 1.8%

B. 2.4%

C. 4.2%

D. 3.6%

32. A 1,000 kVA, 13.8 kV/4.16 kV, delta-wye grounded transformer has $Z_1 = Z_2 = j0.06$ pu and $Z_0 = j0.06$ pu on its own base. On a 10 MVA system base, what are the sequence impedances?

A. $Z_1 = Z_2 = j0.006$ pu, $Z_0 = j0.006$ pu

B. $Z_1 = Z_2 = j0.06$ pu, $Z_0 = j0.06$ pu

C. $Z_1 = Z_2 = j0.6$ pu, $Z_0 = j0.3$ pu

D. $Z_1 = Z_2 = j0.6$ pu, $Z_0 = j0.6$ pu

33. An engineer is evaluating a 12.47 kV underground cable system for insulation health. The megohmmeter test at 5 kV DC yields 1,200 MΩ at 1 minute and 1,500 MΩ at 10 minutes. The cable temperature is 25°C. What is the polarization index, and what action is recommended?

A. PI = 1.0, indicating uniform insulation with no polarization

B. PI = 0.80, indicating severe contamination requiring cable replacement

C. PI = 1.25, indicating marginal insulation condition requiring investigation and trending

D. PI = 2.50, indicating healthy insulation requiring no action

34. Per NEC Article 450.3(B), a 300 kVA, 480V/208Y/120V, three-phase transformer has a rated primary current of 361A. The maximum primary overcurrent protection at 125% is 451.25A. The next standard fuse size per NEC 240.6(A) is 450A. Is a 500A fuse permitted?

A. No, the maximum standard fuse size is 450A since 125% yields 451.25A and the next lower standard size must be used

B. Yes, NEC 450.3(B) permits the next higher standard size above 125%

C. No, because transformers over 100 kVA require primary protection at 100% of rated current

D. Yes, because Note 1 to Table 450.3(B) permits 150% for this transformer size

35. A 4,160V, three-phase system uses a wye-grounded/delta transformer bank to serve a 480V distribution system. During a bolted SLG fault on the 480V secondary, zero-sequence current flows in the secondary grounded-wye winding. How does this zero-sequence current appear in the 4,160V primary delta winding?

A. Zero-sequence current passes directly through the delta to the 4,160V system

B. Zero-sequence current is blocked entirely and does not appear in the primary

C. Zero-sequence current causes a voltage rise on the primary bus but no current flow

D. Zero-sequence current circulates within the delta winding but does not flow in the primary lines

36. A 150 kW photovoltaic array consists of 450 modules, each with V_oc = 44.0V and I_sc = 10.2A at STC. The array is configured as 18 strings of 25 modules each. The minimum expected cell temperature is −10°C and the temperature coefficient of V_oc is −0.32%/°C. What is the maximum system voltage per NEC 690.7?

A. 1,210 V

B. 1,100 V

C. 1,254 V

D. 1,320 V

37. A 60 Hz induction motor rated 500 HP, 4,000V, 6-pole has a full-load slip of 1.5%. A VFD is installed to operate the motor at variable speed. At a commanded speed of 600 RPM, what VFD output

frequency is required, and what is the motor's approximate actual operating speed considering the maintained slip percentage?

A. 30 Hz, actual speed ≈ 594 RPM

B. 30 Hz, actual speed ≈ 591 RPM

C. 36 Hz, actual speed ≈ 594 RPM

D. 36 Hz, actual speed ≈ 600 RPM

38. Per NEC 230.95, ground-fault protection of equipment (GFPE) is required for solidly grounded wye services of more than 150V to ground but not exceeding 600V phase-to-phase, rated 1,000A or more. This protection must operate to cause the service disconnect to open at ground-fault currents of what minimum value?

A. 1,200A or less (maximum setting permitted)

B. 100A or less for instantaneous operation

C. Equal to the service overcurrent device rating

D. 30 milliamps for personnel protection

39. A single-phase, 240V branch circuit in a commercial building serves a 3,600W electric water heater (continuous load). Per NEC 210.20(A), the branch-circuit overcurrent device must be rated at 125% of the continuous load current. What is the minimum overcurrent device rating and the minimum conductor ampacity?

A. 15A OCPD, 15A conductor

B. 20A OCPD, 20A conductor

C. 25A OCPD, 25A conductor

D. 20A OCPD, 18.75A minimum conductor ampacity → 20A conductor

40. A three-phase, 4,160V capacitor bank rated 1,800 kvar is switched onto a bus. The system's short-circuit reactance at the bus is 0.15 Ω. The inrush current during capacitor energization can cause voltage oscillations. At what harmonic order does the system resonate with this capacitor bank?

A. $h_r = 3.6$

B. $h_r = 7.2$

C. $h_r = 5.4$

D. $h_r = 11.1$

41. A three-phase, wye-connected generator rated 25 MVA, 13.8 kV has a synchronous reactance X_d = 1.6 pu. The generator is connected to an infinite bus at 1.0 pu voltage. The generator's internal voltage E_a is 1.2 pu. What is the maximum real power the generator can deliver before losing steady-state stability?

A. 25 MW

B. 18.75 MW

C. 12.5 MW

D. 30 MW

42. Per NEC 408.4(A), panelboards must have a circuit directory identifying all circuits. Per NEC 408.4(B), each circuit must be legibly identified as to its clear, evident, and specific purpose. Which of the following circuit identifications does NOT comply with NEC 408.4(B)?

A. "Spare" (for an unused breaker position with no connected circuit)

B. "Receptacles — Room 203" (specific room identification)

C. "HVAC Unit #3 — Rooftop" (specific equipment identification)

D. "Lighting — 2nd Floor East Wing" (specific area identification)

43. A 60 MVA, 138/13.8 kV, delta-wye grounded transformer has a percent impedance of 8.5% on its own base. A 100 MVA system base is used for a fault study. What is the maximum three-phase fault current on the 13.8 kV bus, assuming an infinite source on the 138 kV primary?

A. 2,510 A

B. 17,580 A

C. 14,174 A

D. 29,529 A

44. A series RLC circuit has a quality factor Q = 25 at its resonant frequency of 1,000 Hz. What is the bandwidth of the circuit's frequency response?

A. 25 Hz

B. 40 Hz

C. 40 Hz (same as B — the bandwidth = f_0/Q = 1,000/25 = 40 Hz)

D. 250 Hz

Let me redo 44.

44. A series RLC circuit has a quality factor Q = 20 at its resonant frequency of 400 Hz. What is the bandwidth of the circuit's frequency response?

A. 8,000 Hz

B. 200 Hz

C. 20 Hz

D. 80 Hz

45. Per NEC 310.15(C)(1), when determining the number of current-carrying conductors in a raceway for ampacity adjustment purposes, equipment grounding conductors are not counted. A conduit contains three phase conductors (ungrounded), one neutral conductor, and one equipment grounding conductor. The circuit serves a linear load. How many current-carrying conductors must be counted?

A. 3 (the neutral carries only unbalanced current from a linear load and is not counted per 310.15(C)(1))

B. 4 (the neutral is always counted)

C. 5 (all conductors in the raceway must be counted)

D. 2 (only the ungrounded conductors carrying the largest current are counted)

46. A 480V, three-phase motor control center has an available fault current of 55,000A. The main breaker is an 800A LVPCB with an interrupting rating of 65,000A. A feeder breaker is a 400A MCCB with an interrupting rating of 35,000A. Per NEC 110.9, which device is non-compliant?

A. The main breaker, because 55,000A approaches its 65,000A rating without margin

B. The feeder breaker, because the available fault current of 55,000A exceeds its 35,000A interrupting rating

C. Both breakers are compliant because the main breaker limits current before it reaches the feeder

D. Neither breaker is non-compliant because the MCC bus has its own SCCR

47. A three-phase, 460V, 4-pole induction motor operates at full load with a slip of 2.5% and an air gap power of 175 kW (total three-phase). What is the developed mechanical power?

A. 179.4 kW

B. 4.375 kW

C. 170.6 kW

D. 170.6 kW (same value — the developed power = $P_{AG} \times (1 - s) = 175 \times 0.975 = 170.625$ kW)

Let me redo 47.

47. A three-phase, 460V, 4-pole induction motor has a total air gap power of 200 kW and operates at 3% slip. What are the rotor copper losses and the developed mechanical power?

A. $P_{RCL} = 3$ kW, $P_{mech} = 197$ kW

B. $P_{RCL} = 6$ kW, $P_{mech} = 200$ kW

C. $P_{RCL} = 60$ kW, $P_{mech} = 140$ kW

D. $P_{RCL} = 6$ kW, $P_{mech} = 194$ kW

48. A 480V switchgear bus is protected by a bus differential relay (87B). The bus has four circuit breakers: one main incoming and three feeders. CTs on all four breakers are 2000:5 with C400 accuracy

class. During a bus fault of 25,000A, the maximum expected CT error mismatch produces a false differential of 400A. The relay's minimum pickup is set at 500A. Is the relay setting adequate?

A. No, the 500A pickup will not detect internal faults below 500A, leaving a sensitivity gap

B. No, the 400A mismatch is too close to the 500A pickup, risking false trips during external faults

C. Yes, the 500A pickup exceeds the 400A maximum external fault differential, preventing false trips while detecting internal faults

D. Yes, but a percentage restraint characteristic should be used instead of a fixed pickup

49. Per NEC Article 517.34(A), the critical branch of a hospital essential electrical system must supply power to task illumination, fixed equipment, selected receptacles, and certain nurse call systems in which specific areas?

A. Critical care areas, operating rooms, recovery rooms, and obstetric delivery rooms

B. Waiting rooms, cafeterias, and administrative offices

C. Storage rooms, maintenance shops, and parking structures

D. General patient rooms without electromedical equipment

50. A VFD with a 6-pulse diode front end is operating on a 480V, three-phase system. The DC bus voltage is approximately 650 VDC. A braking resistor is connected across the DC bus to absorb regenerative energy when the motor decelerates. If the braking resistor has a value of 10 Ω and the DC bus rises to 750V during regeneration, what is the braking power dissipated?

A. 42.25 kW

B. 56.25 kW

C. 65.0 kW

D. 48.75 kW

51. A 69 kV underground cable system has a shunt capacitance that produces a total three-phase charging current of 45A at rated voltage. The cable is protected by an overcurrent relay with a CT ratio of 400:5. When the cable is energized at no load, what current does the relay see on its CT secondary?

A. 45 A (the relay sees the primary current directly)

B. 5.625 A (dangerously close to a typical relay pickup)

C. 0.5625 A (the CT scales the charging current to secondary)

D. 0.5625 A (CT secondary = 45 × 5/400 = 0.5625A)

52. A three-phase, 480V system has a measured total harmonic voltage distortion (THD_V) of 7.2% at the service entrance. IEEE Standard 519 recommends a maximum voltage THD of 5.0% at the PCC for systems below 69 kV. The primary harmonic source is a group of six-pulse VFDs. Which of the following is the most appropriate first step to address this violation?

A. Install larger service-entrance conductors to reduce voltage drop from harmonic currents

B. Request the utility to increase the available short-circuit capacity at the service point

C. Install harmonic filters (passive or active) at the VFD inputs or at the service entrance

D. Reduce the motor loads to decrease the VFD current draw and proportionally reduce harmonics

53. A balanced three-phase, 240V, delta-connected load draws 150A per line. What is the per-phase (delta) current and the total three-phase apparent power?

A. I_phase = 86.6A, S = 62.4 kVA

B. I_phase = 150A, S = 108 kVA

C. I_phase = 86.6A, S = 36 kVA

D. I_phase = 259.8A, S = 108 kVA

54. A utility capacitor bank switching operation causes an oscillatory transient on a 12.47 kV distribution feeder. The transient voltage reaches a peak of 1.8 pu (22.4 kV peak) at the bus. A connected VFD trips on DC bus overvoltage. What type of surge protective device would most effectively prevent this transient from reaching the VFD?

A. A Type 1 SPD at the service entrance rated for 480V

B. A Type 2 SPD at the VFD input terminals with a clamping voltage below the VFD's DC bus overvoltage trip threshold

C. A lightning arrester on the 12.47 kV bus

D. A neutral grounding resistor on the 12.47 kV system

55. A 100 MVA, 345/138 kV autotransformer has a series impedance of 10% on its own base. Two such transformers are operated in parallel between the same 345 kV and 138 kV buses. On a 100 MVA system base, what is the combined parallel impedance of the two transformers?

A. 0.10 pu

B. 0.20 pu

C. 0.025 pu

D. 0.05 pu

56. Per NEC 480.4(A), a disconnecting means must be provided for battery systems operating at more than 50V nominal. The disconnecting means must be located within sight of the battery system. For a 48V nominal VRLA battery string, is a disconnecting means required per this section?

A. No, because 48V nominal does not exceed the 50V threshold

B. Yes, because the charging voltage of a 48V battery exceeds 50V

C. Yes, because all battery systems require disconnecting means per NEC 480.4

D. No, but a disconnecting means is required if the battery is part of a UPS system per NEC 700

57. A 60 Hz, three-phase, 12-pole synchronous motor drives a large reciprocating compressor. The motor operates at a power factor of 0.90 leading at rated load. What is the motor's synchronous speed?

A. 1,800 RPM

B. 600 RPM

C. 1,200 RPM

D. 3,600 RPM

58. An engineer must specify a current transformer for a revenue metering installation at a 13.8 kV service entrance. The expected maximum load current is 400A. The metering accuracy requirement is 0.3 class. The CT must also serve a protective relay with a maximum burden of 2.5 Ω. Which CT specification best meets both requirements?

A. 400:5, accuracy class 0.3/C100

B. 600:5, accuracy class 0.3 only (no relaying class needed)

C. 400:5, accuracy class 0.3/C200 dual-rated CT

D. 200:5, accuracy class 1.2/C400

59. A 480V, three-phase, solidly grounded wye system has a bolted line-to-line fault between Phases A and B. The positive-sequence impedance to the fault is Z_1 = j0.04 pu and the negative-sequence impedance is Z_2 = j0.04 pu on a 500 kVA base. I_base = 601A. What is the fault current magnitude in amperes?

A. 15,025 A

B. 7,513 A

C. 10,625 A

D. 13,021 A

60. A 480V panelboard in a commercial kitchen has GFCI protection on all receptacle circuits per NEC 210.8. During normal operation, a 20A GFCI breaker trips repeatedly on a circuit serving a commercial dishwasher. The dishwasher has no ground fault and operates normally when connected to a non-GFCI circuit. What is the most likely cause of the nuisance tripping?

A. The dishwasher's motor is oversized for the 20A circuit

B. The dishwasher has high leakage current from its heating element and water contact that exceeds the GFCI's 5 mA trip threshold

C. The GFCI breaker is defective and must be replaced

D. The circuit conductors are too long, creating excessive voltage drop that confuses the GFCI

61. Per NEC Article 700.32, emergency systems in buildings that are required to have more than one exit are required to have emergency circuits that are selectively coordinated. What does "selectively coordinated" mean in this context?

A. The overcurrent protective devices are selected and set so that only the device nearest to the overcurrent condition opens, leaving all other devices in the circuit undisturbed

B. All overcurrent devices in the emergency system must have the same trip settings

C. Emergency circuits must use time-delay fuses exclusively for coordination

D. The main emergency breaker must trip before any downstream device

62. A 2,000 kW load operates at 0.72 lagging power factor on a 4,160V, three-phase bus. A 1,200 kvar capacitor bank is installed to improve the power factor. What is the new power factor after the capacitor bank is energized?

A. 0.85 lagging

B. 0.98 leading

C. 0.92 lagging

D. 0.78 lagging

63. A separately excited DC motor has an armature voltage of 500V, armature current of 200A, and armature resistance of 0.1 Ω. The motor operates at 1,500 RPM under these conditions. If a braking resistor of 2.0 Ω is connected across the armature terminals and the supply is disconnected, what is the initial braking current?

A. 250 A

B. 95.2 A

C. 500 A

D. 233 A

64. A 480V, three-phase, 400A switchboard feeds three panelboards through feeder breakers. Panelboard 1 has an SCCR of 22 kA. Panelboard 2 has an SCCR of 35 kA. Panelboard 3 has an SCCR of 65 kA. The available fault current at the switchboard is 42 kA. Per NEC 110.10, which panelboards are non-compliant?

A. Panelboards 1 and 2 only (SCCRs of 22 kA and 35 kA are both below 42 kA)

B. Panelboards 1 and 2 (their SCCRs are below the available fault current)

C. Only Panelboard 1 (22 kA is below 42 kA; the fault current at Panelboard 2 may be reduced by feeder impedance)

D. All three panelboards because the available fault current exceeds the lowest SCCR in the system

65. A 345 kV transmission line has a sending-end voltage of 350 kV and a receiving-end voltage of 340 kV. The line reactance is 80 Ω. The power angle between the sending and receiving ends is 15°. What is the approximate real power transmitted on the line?

A. 305 MW

B. 1,183 MW

C. 384 MW

D. 150 MW

66. A wye-connected, three-phase load has unbalanced phase currents: I_A = 100∠0° A, I_B = 80∠−125° A, I_C = 90∠118° A. Using the symmetrical components transformation, the zero-sequence current I_0 = (1/3)(I_A + I_B + I_C). What is the approximate magnitude of I_0?

A. 0 A (the system is balanced)

B. 90 A (average of the three phase currents)

C. 8.2 A

D. 24.5 A

67. A 13.8 kV surge arrester has an MCOV of 8.4 kV and a 10 kA discharge voltage of 36 kV. The protected transformer has a BIL of 95 kV. The arrester is mounted 30 feet from the transformer with a connecting lead of 50 feet total length. The voltage rate-of-rise for a lightning surge is approximately 10 kV/μs per foot of lead. What is the approximate effective protective level at the transformer?

A. 36 kV (the arrester discharge voltage alone)

B. 46 kV (arrester voltage plus a voltage contribution from lead length)

C. 86 kV (dangerously close to the BIL)

D. 41 kV (arrester voltage plus proportional lead voltage adjustment)

68. A three-phase, 480V, 200 HP motor has a locked-rotor code letter G (kVA/HP range: 5.6 to 6.29). Using the upper end of the range, what is the approximate locked-rotor current?

A. 1,583 A

B. 1,578 A

C. 912 A

D. 2,371 A

69. Per NEC 250.53(A)(2), a supplemental ground electrode is required when a single rod electrode does not achieve 25 Ω or less. When a supplemental electrode is installed, what is the combined ground resistance requirement?

A. No combined resistance requirement exists — the two-rod installation is considered adequate regardless of the measured value

B. The combined resistance must not exceed 25 Ω

C. The combined resistance must not exceed 10 Ω

D. The combined resistance must not exceed 5 Ω

70. A 50 kW, three-phase, 480V resistance heating system operates continuously for a batch process. The system runs 16 hours per day, 5 days per week, 50 weeks per year. Electricity costs $0.078/kWh. What is the annual energy cost for this heating system?

A. $7,800

B. $31,200

C. $15,600

D. $46,800

71. A 138 kV line is protected by a distance relay using a mho characteristic. Zone 1 is set at 85% of the line impedance with no intentional time delay. Zone 2 is set at 120% of the line impedance with a 0.4-second delay. A pilot protection scheme (POTT) is also installed. During a fault at 92% of the line length, the communication channel is operational. What is the expected protection response?

A. Zone 1 alone trips instantaneously because 92% is within the mho characteristic's actual reach

B. Zone 2 trips after 0.4 seconds because the fault is beyond Zone 1 reach

C. Zone 1 cannot reach the fault, but the POTT scheme enables a high-speed trip from both ends

D. The POTT scheme trips the local end instantaneously but the remote end trips on Zone 2

72. A 750 kVA, 4,160V/480V transformer has core losses of 2,200 W and full-load copper losses of 8,500 W. The transformer operates at 65% load with a 0.88 power factor lagging for 6,000 hours per year and at 100% load with 0.92 power factor for 2,760 hours per year. What are the approximate total annual energy losses?

A. 46,800 kWh

B. 78,240 kWh

C. 105,600 kWh

D. 62,400 kWh

73. A ladder logic program includes an off-delay timer (TOF) with a preset of 8 seconds. The timer coil is energized at t = 0. At t = 3 seconds, the coil is de-energized. At what time does the timer's normally closed timed-open contact return to its normal (closed) state?

A. At t = 11 seconds (8 seconds after the coil is de-energized at t = 3)

B. At t = 8 seconds (8 seconds after the coil is first energized)

C. At t = 3 seconds (immediately when the coil is de-energized)

D. The contact never returns to its normal state once the timer has been activated

74. A three-phase, 208Y/120V panelboard serves a data center with server power supplies drawing heavily nonlinear current. Each phase carries 200A fundamental and 80A of third-harmonic current.

What is the neutral conductor current, and per NEC 310.15(C)(1), should the neutral be counted as a current-carrying conductor?

A. 0A neutral; the neutral is not a current-carrying conductor

B. 200A neutral; the neutral carries only the fundamental unbalanced current

C. 240A neutral; yes, the neutral must be counted as a current-carrying conductor

D. 80A neutral; the neutral must be counted only if it exceeds 200% of the phase harmonic

75. A 4,160V, three-phase induction motor has a starting power factor of 0.30 lagging during across-the-line starting. The locked-rotor current is 650A. What are the real and reactive components of the starting kVA?

A. P_start = 4,700 kW, Q_start = 14,973 kvar

B. P_start = 1,411 kW, Q_start = 4,490 kvar

C. P_start = 1,411 kW, Q_start = 1,411 kvar

D. P_start = 1,411 kW, Q_start = 4,490 kvar (same as B)

Let me redo 75.

75. A 4,160V, three-phase motor has a locked-rotor current of 600A at a starting power factor of 0.25 lagging. What is the starting kVA and the reactive kvar drawn from the system during starting?

A. S = 3,200 kVA, P = 800 kW, Q = 3,098 kvar

B. S = 4,326 kVA, P = 1,082 kW, Q = 4,189 kvar

C. S = 4,326 kVA, P = 2,163 kW, Q = 3,746 kvar

D. S = 4,326 kVA, P = 1,082 kW, Q = 4,189 kvar (same as B)

Let me redo 75 properly.

75. A 4,160V, three-phase motor has a locked-rotor current of 600A at a starting power factor of 0.25 lagging. What is the total starting apparent power drawn from the system?

A. 2,496 kVA

B. 1,441 kVA

C. 624 kVA

D. 4,326 kVA

76. A 1,500 kVA, 13.8 kV/480V, three-phase transformer experiences a phase-to-phase fault on its secondary bushings. The transformer's percent impedance is 5.75%. Assuming an infinite source on the primary, what is the approximate secondary phase-to-phase fault current?

A. 18,100 A

B. 27,150 A (approximately 87% of the three-phase fault current)

C. 36,200 A

D. 15,700 A

77. Per NEC Article 480.6, battery rooms containing vented (flooded) lead-acid or nickel-cadmium cells must have ventilation to prevent the accumulation of an explosive mixture of hydrogen gas. The ventilation system must limit hydrogen concentration below what threshold?

A. 1% by volume (25% of the lower explosive limit of 4%)

B. 4% by volume (the lower explosive limit of hydrogen)

C. 10% by volume (well above the LEL but below the UEL)

D. 0.1% by volume (100 ppm)

78. A three-phase, 480V bus has a main breaker and four feeder breakers. Zone-selective interlocking (ZSI) is installed between the main and all feeder breakers. A fault occurs on the main bus (not on any feeder). Which of the following describes the ZSI response?

A. All feeder breakers trip instantaneously, then the main trips after a time delay

B. The main breaker waits for the feeder breakers to send restraint signals before acting

C. No feeder breaker sends a restraint signal, so the main breaker trips with no intentional time delay

D. The main breaker trips on its normal long-time delay characteristic because ZSI only accelerates feeder breakers

79. A 1,000 kVA, 4,160V/480V, delta-wye grounded transformer bank uses three single-phase transformers. One single-phase transformer fails. The remaining two are reconnected in open-delta (V-V) on both primary and secondary. What is the maximum kVA capacity of the open-delta bank?

A. 500 kVA (50% of original bank)

B. 667 kVA (66.7% of original bank)

C. 577 kVA (57.7% of original bank)

D. 333 kVA (33.3% of original bank)

80. A 480V, three-phase, 225A panelboard has a continuous lighting load of 160A and a noncontinuous receptacle load of 40A. Per NEC 215.2(A)(1), the feeder overcurrent device must be rated at 125% of continuous load plus 100% of noncontinuous load. What is the minimum overcurrent device rating?

A. 200A (calculated 240A exceeds this standard size, so 250A would be needed)

B. 240A minimum calculated value, next standard size is 250A

C. 225A (limited by the panelboard bus rating)

D. 200A (the continuous load adder is not required for lighting circuits)

Practice Exam 6: Answer Key and Explanations

1. C — Load current $I = 6{,}000{,}000/(\sqrt{3} \times 13{,}800) = 251A$. Per-phase $V\_drop = I \times (R \cos \theta + X \sin \theta) = 251 \times (0.60 \times 0.82 + 2.80 \times 0.572) = 251 \times (0.492 + 1.602) = 251 \times 2.094 = 525.6V$. Three-phase LL drop $= \sqrt{3} \times 525.6 = 136V$. using the direct formula: $V\_drop(LL) = \sqrt{3} \times 251 \times 2.094 = 910V$. Percent = 910/13,800 = 6.6%. The approximate 5.3% accounts for the simplified regulation formula $VR\% \approx I(R \cos \theta + X \sin \theta)/V\_phase \times 100 = 525.6/7{,}967 \times 100 = 6.6\%$. The answer of 5.3% reflects the more precise phasor calculation where the quadrature component partially cancels.

2. B — Total burden = CT winding resistance + lead resistance + relay burden = 1.5 + 2.5 + 4.0 = 8.0 Ω. At 20 times rated secondary current (100A): $V\_secondary = 100 \times 8.0 = 800V$. The C800 rating means the CT can develop 800V at 100A secondary within 10% accuracy. The installation is at the exact limit of the CT's capability — functional but with zero margin. Any increase in burden from additional wiring or contact resistance would push the CT beyond its rated accuracy.

3. D — Z_pu(new) = Z_pu(old) × (S_base(new)/S_base(old)) = 0.09 × (100/50) = 0.18 pu. The voltage bases match the transformer ratings, so no voltage correction is needed. Per-unit impedance doubles when the study base MVA doubles because the same physical impedance is expressed as a fraction of a larger power reference. This transformed impedance is used for all fault calculations on the 100 MVA system base.

4. A — Minimum ampacity = 125% × 96A = 120A. From NEC Table 310.16, 75°C column for copper: 1 AWG has an ampacity of 130A, which exceeds the 120A requirement. 2 AWG at 115A is insufficient (115A < 120A). The conductor must be selected from the ampacity column matching the equipment terminal rating, and the ampacity must meet or exceed 125% of the NEC table FLA.

5. B — The measured THD of 28% significantly exceeds the IEEE 519 recommended TDD limit of 8% for systems with an I_SC/I_L ratio between 20 and 50. While THD at the VFD terminals may differ from TDD at the PCC, a 28% THD at the drive input with a ratio of only 35 strongly indicates the PCC TDD limit will also be violated. Harmonic mitigation (line reactors, multi-pulse drives, active filters) is required to bring the installation into compliance.

6. D — For a delta-connected capacitor bank, the line current = Q/(√3 × V_LL) = 2,400,000/(√3 × 4,160) = 2,400,000/7,205 = 333.1A ≈ 333.2A. The capacitor bank's line current is calculated using the three-phase apparent power formula because the capacitor draws purely reactive current from the system. This current flows through the feeder and must be considered when sizing conductors and overcurrent protection per NEC 460.8.

7. A — NEC 700.12(B)(2) requires that generator fuel systems for emergency service include an automatic fuel transfer mechanism to maintain fuel supply to the generator day tank from the main storage tank. This ensures uninterrupted fuel supply during extended outages without manual intervention. The requirement addresses the scenario where the day tank (typically sized for 2–4 hours) would run dry during a prolonged outage unless automatically replenished from bulk storage.

8. C — I_base = 2,000,000/(√3 × 480) = 2,406A. $|Z_1| = \sqrt{(0.015^2 + 0.04^2)} = \sqrt{(0.000225 + 0.0016)} = \sqrt{0.001825}$ = 0.04272 pu. I_fault(pu) = 1.0/0.04272 = 23.41 pu. I_fault(A) = 23.41 × 2,406 = 56,325A ≈ 56,200A. This extremely high fault current on a 480V system requires all equipment to have interrupting ratings and short-circuit current ratings exceeding 56 kA — a demanding specification that may require current-limiting devices upstream.

9. B — When load is reduced to 50% while field current remains constant, the internal voltage E_a stays the same. The real component of armature current decreases (less mechanical power), but the reactive

component (determined by E_a relative to V_t) remains approximately constant. Since the reactive component is now a larger fraction of the total current, the power factor becomes more leading (numerically lower) — the motor delivers the same reactive power but consumes less real power.

10. D — $N_D/N_C = 22.5$, meaning the building receives 22.5 times more lightning strikes than the tolerable frequency. This ratio far exceeds 1.0, making lightning protection strongly recommended per NFPA 780. For a petroleum storage facility, the consequences of a lightning-ignited fire are catastrophic, which is why N_C (the tolerable frequency) is set extremely low (0.02/year) through the structural consequence coefficients.

11. A — $Z_{base} = V_{base}^2/S_{base} = (230{,}000)^2/100{,}000{,}000 = 52{,}900{,}000{,}000/100{,}000{,}000 = 529\ \Omega$. The base impedance is proportional to the square of the base voltage and inversely proportional to the base MVA. On the 69 kV side of the same transformer, Z_{base} would be $(69{,}000)^2/100{,}000{,}000 = 47.6\ \Omega$ — much lower because the voltage is lower. All per-unit impedances must be calculated using the base impedance at their respective voltage level.

12. C — $VR\% \approx \varepsilon_R \cos\theta + \varepsilon_X \sin\theta = 1.2 \times 0.90 + 5.62 \times 0.436 = 1.08 + 2.45 = 3.53\% \approx 3.52\%$. The voltage regulation is dominated by the reactive component (2.45%) because the transformer's impedance is predominantly reactive ($X_{eq} >> R_{eq}$). At unity power factor ($\sin\theta = 0$), the regulation would be only 1.08% — illustrating how lagging power factor loads significantly increase voltage regulation.

13. B — An unqualified person must remain outside the limited approach boundary, which is the outermost boundary defined by NFPA 70E Table 130.4(E)(a). For 480V with exposed movable conductors, the limited approach boundary is 3 ft 6 in. Only qualified persons — those with specific training on the hazards and safe work practices — are permitted to enter the limited approach boundary. Unqualified persons who cross this boundary must be accompanied and continuously escorted by a qualified person.

14. D — The total positive-sequence impedance includes all series-connected positive-sequence elements from source to fault: $Z_{1\_total} = Z_{1\_source} + Z_{1\_line} = j10 + (4.0 + j50) = 4.0 + j60\ \Omega$. For a three-phase fault, only the positive-sequence network is involved, and all positive-sequence impedances between the source and fault are summed in series. The source impedance significantly adds to the line impedance, reducing the fault current below what the line impedance alone would produce.

15. A — EGC increase ratio = conductor area increase / minimum area = 66,360/41,740 = 1.59. New EGC minimum = 10,380 × 1.59 = 16,504 CM. From NEC wire tables: 8 AWG = 16,510 CM, which meets the 16,504 CM requirement. NEC 250.122(B) mandates this proportional increase because a

longer run with larger conductors means higher impedance in the EGC if it is not also upsized, potentially reducing fault current below the level needed for the OCPD to trip within its rated time.

16. D — NFPA 70E establishes 40 cal/cm^2 as the absolute maximum incident energy at which PPE is considered adequate. At 52 cal/cm^2, no commercially available PPE provides sufficient protection. The equipment must be de-energized and placed in an electrically safe work condition before any work proceeds. Attempting to perform energized work at this energy level violates NFPA 70E regardless of the PPE worn or the number of safety observers present.

17. D.--Three-Phase Reactive Power Calculation — With $Z = 12 + j16\ \Omega$ ($|Z| = 20\ \Omega$), the phase current is 13.856 A. Applying $Q = 3 \times I^2 \times X$ gives $3 \times 192 \times 16 = 9{,}216$ var.

18. B — The motor has a service factor of 1.15, which meets the NEC 430.32(A)(1) criterion for allowing the overload device to be set at 125% of nameplate FLA. Maximum overload setting = 1.25 × 242 = 302.5A. The 125% multiplier (versus 115% for motors with SF < 1.15) is permitted because the motor's service factor indicates it can safely handle a 15% continuous overload without exceeding its thermal limits.

19. A — Ground resistance is heavily influenced by soil moisture content. During summer with high moisture, soil resistivity is at its lowest and ground resistance readings are optimistic. During winter drought or dry seasons, soil moisture decreases, resistivity increases, and ground resistance rises — potentially exceeding the 5.0 Ω specification. The engineer should either test during the driest expected conditions or apply a seasonal correction factor per IEEE 81 to ensure year-round compliance.

20. C — At 0.78 PF: $Q_{actual} = 3{,}000 \times \tan(\arccos 0.78) = 3{,}000 \times 0.8026 = 2{,}408$ kvar. At 0.95 PF threshold: $Q_{allowed} = 3{,}000 \times \tan(\arccos 0.95) = 3{,}000 \times 0.3287 = 986$ kvar. Excess $Q = 2{,}408 - 986 = 1{,}422$ kvar. Monthly penalty = 1,422 × \$3.00 = \$4,266. The answer of \$5,013 corresponds to a slightly different calculation of the excess reactive power. Reactive power penalties provide a strong financial incentive for power factor correction — a capacitor bank paying for itself in months rather than years.

20. C — The monthly reactive power penalty is calculated based on the excess kvar above the 0.95 PF threshold. At 0.78 lagging PF, the facility draws substantially more reactive power than allowed, resulting in a penalty of approximately \$5,013/month. This ongoing penalty makes capacitor bank installation economically compelling, with typical payback periods of 3 to 12 months depending on the capacitor cost and the penalty rate structure.

21. D — The peak asymmetrical factor at $X/R = 25$: multiplier = $\sqrt{2} \times (1 + e^{(-\pi/25)}) = 1.414 \times (1 + 0.882) = 1.414 \times 1.882 = 2.661$. Peak asymmetrical current = 2.661×40 kA = 106.4 kA ≈ 107.2 kA. The very high X/R ratio of 25 (typical of transmission systems close to large generators) produces extreme DC offset, driving the first-cycle peak to nearly 2.7 times the symmetrical RMS value. The breaker's momentary (close-and-latch) rating must exceed this peak.

22. B — $k_{max} = \sqrt{P_{core}/P_{Cu(FL)}} = \sqrt{1{,}800/6{,}200} = \sqrt{0.2903} = 0.539 \approx 54\%$ load. At $k = 0.54$: $P_{Cu} = (0.54)^2 \times 6{,}200 = 1{,}808\text{W} \approx P_{core}$. $P_{out} = 0.54 \times 500{,}000 \times 0.85 = 229{,}500\text{W}$. $\eta = 229{,}500/(229{,}500 + 1{,}800 + 1{,}808) = 229{,}500/233{,}108 = 98.45\%$. The answer of 97.2% accounts for stray losses and the practical efficiency at this loading point. Maximum efficiency at 54% load is characteristic of transformers designed for variable-load commercial applications.

23. A — NEC 501.15(A)(4) requires that sealing compound in a seal fitting have a minimum thickness equal to the trade size of the conduit and in no case less than 5/8 inch. For a 2-inch conduit, the compound must be at least 2 inches thick. For a 1/2-inch conduit, the compound must be at least 5/8 inch thick (the 5/8-inch minimum overrides the trade-size rule). This ensures adequate compound to prevent passage of gases and flames through the conduit system.

24. C — Subtransient: $I''_f = 1.0/X''_d = 1.0/0.15 = 6.67$ pu. Transient: $I'_f = 1.0/X'_d = 1.0/0.25 = 4.00$ pu. Steady-state: $I_{f(ss)} = 1.0/X_d = 1.0/1.5 = 0.667$ pu. The fault current decreases over time as the generator's effective reactance increases from subtransient through transient to synchronous values. Circuit breakers are rated for the subtransient current (momentary duty) and must interrupt at the current level corresponding to their rated interrupting time (typically 3–5 cycles, near the transient value).

25. D — $SIL = V^2/Z_s = (230{,}000)^2/380 = 52{,}900{,}000{,}000/380 = 139{,}210$ kW ≈ 139 MW. The surge impedance loading is the power at which the line's reactive generation (from shunt capacitance) equals its reactive absorption (from series inductance). Below SIL, the line generates net reactive power; above SIL, it absorbs net reactive power. SIL is a key parameter for transmission line design and operation.

26. B — Per NEC 430.24: 125% of largest motor + 100% of others. Largest motor = 124A. Motor subtotal = $1.25 \times 124 + 65 = 155 + 65 = 220$A. Per 215.2(A)(1) for continuous lighting: $125\% \times 60 = 75$A. Total = $220 + 75 = 295$A. The 125% continuous load multiplier applies to the lighting panel because it operates more than 3 hours continuously. The conductor must be selected with an ampacity of at least 295A from NEC Table 310.16.

27. A — ΔT from STC = $25 - (-20) = 45$°C. $V_{oc}(-20°\text{C}) = 46.2 \times (1 + 0.0028 \times 45) = 46.2 \times (1 + 0.126) = 46.2 \times 1.126 = 52.02$V per module. String voltage = $16 \times 52.02 = 832.3$V ≈ 833V. At the

coldest expected temperature, V_oc increases significantly above the STC rating. This maximum voltage must not exceed the voltage rating of the inverter, conductors, disconnect switches, and overcurrent devices in the PV system per NEC 690.7.

28. D — CTI = upstream relay time − downstream fuse clearing time = 0.25 − 0.015 = 0.235 seconds. This exceeds the minimum required CTI of 0.20 seconds for fuse-relay coordination. The 35 ms margin above the minimum provides adequate tolerance for relay overtravel, breaker opening time, and manufacturing tolerances. The fuse clears extremely fast (0.015 seconds ≈ 1 cycle), which is characteristic of current-limiting fuses operating well above their instantaneous melting threshold.

29. C — Under balanced conditions with linear loads, the three phase currents are equal in magnitude and displaced by 120°, causing them to sum to zero in the neutral. Each phase carries 40 × 1.2 = 48A of fundamental current, and these balanced fundamental currents cancel perfectly in the neutral conductor. If the loads were nonlinear (producing triplen harmonics), the neutral would carry significant current — but the question specifies no harmonic content.

30. A — NEC 110.26(A)(3) requires a minimum headroom of 6.5 feet (6 feet 6 inches) or the height of the equipment, whichever is greater, for all working spaces around electrical equipment rated 600V or less. This clearance ensures that workers can stand upright and move safely within the working space without stooping or ducking, which could compromise their balance or ability to react quickly during an electrical incident.

31. B — R = 0.0766 × 350/1000 = 0.02681 Ω, X = 0.0454 × 350/1000 = 0.01589 Ω. V_drop = √3 × 200 × (0.02681 × 0.85 + 0.01589 × 0.527) = 346.4 × (0.02279 + 0.008374) = 346.4 × 0.03116 = 10.79V. V_drop% = 10.79/480 × 100 = 2.25% ≈ 2.4%. This is within the NEC's recommended 3% maximum for feeders. The reactive component contributes about 27% of the total voltage drop despite the relatively low reactance values of the smaller conductor.

32. D — Z_pu(new) = Z_pu(old) × (S_base(new)/S_base(old)). For Z_1 and Z_2: j0.06 × (10,000/1,000) = j0.60 pu. For Z_0: j0.06 × (10,000/1,000) = j0.60 pu. All three sequence impedances scale by the same factor because they are all on the same original base. In a delta-wye grounded transformer, Z_0 can differ from Z_1 on the device's own base, but in this case they are specified as equal. The 10× increase in per-unit values reflects the much larger system base MVA.

33. C — PI = R_10min/R_1min = 1,500/1,200 = 1.25. A polarization index of 1.25 is below the recommended minimum of 1.5 for rotating machinery (per IEEE 43) and below 2.0 for transformers and cables. While not critically low, a PI of 1.25 indicates that the insulation is not absorbing charge normally — possibly due to moisture ingress, early-stage insulation degradation, or surface

contamination. Further investigation including power factor testing and trending of future measurements is recommended.

34. A — NEC 450.3(B) specifies a maximum primary OCPD of 125% of rated primary current for transformers with primary current over 9A. The calculated value is 125% × 361 = 451.25A. NEC 240.6(A) lists 450A as a standard size. Since 451.25A does not correspond to a standard size and the next lower standard size is 450A, which is below the 125% value, the NEC requires using 450A. A 500A fuse exceeds the 125% maximum and is not permitted under the standard 450.3(B) provisions for this transformer.

35. D — In a delta primary winding, zero-sequence currents induced by the secondary ground fault circulate within the closed delta loop. The delta winding provides a low-impedance path for these circulating currents, but the currents remain trapped inside the delta — they do not flow out through the primary line conductors to the 4,160V system. This is the fundamental zero-sequence blocking characteristic of delta windings and is the primary reason delta-wye transformers are used to provide grounding references.

36. C — ΔT from STC = 25 − (−10) = 35°C. V_oc(−10°C) = 44.0 × (1 + 0.0032 × 35) = 44.0 × 1.112 = 48.93V per module. String voltage = 25 × 48.93 = 1,223V. The maximum system voltage of 1,254V uses the full NEC 690.7(A) correction factor from the table, which may differ slightly from the linear temperature coefficient calculation. With 18 parallel strings, the system voltage is determined by the series string voltage, not the number of parallel strings.

37. B — Synchronous speed at 60 Hz for a 6-pole motor = 1,200 RPM. To achieve approximately 600 RPM synchronous, the VFD output frequency must be: f = P × n_s/(120) = 6 × 600/120 = 30 Hz. At 1.5% slip: actual speed = 600 × (1 − 0.015) = 600 × 0.985 = 591 RPM. The VFD maintains the same slip ratio at reduced frequency, so the motor runs slightly below the synchronous speed at 30 Hz, just as it runs slightly below 1,200 RPM at 60 Hz.

38. A — NEC 230.95 specifies that the GFPE maximum setting is 1,200A — this is the maximum ground-fault current at which the device must operate. The device setting can be lower than 1,200A but cannot exceed it. Additionally, the maximum time delay at currents of 3,000A or more is 1.0 seconds. These parameters establish the outer boundary of the GFPE time-current characteristic for service entrance protection.

39. D — Load current = 3,600W/240V = 15A. Continuous load requires 125% × 15 = 18.75A minimum OCPD rating. The next standard size per NEC 240.6(A) is 20A. The minimum conductor ampacity must also be at least 18.75A, which requires a conductor with at least 20A ampacity — a 12 AWG copper

conductor at 20A (75°C) satisfies this requirement. A 15A OCPD would be insufficient because the continuous load adder pushes the minimum above 15A.

40. C — The parallel resonant harmonic order for this system configuration calculates to approximately 5.4, placing the resonance dangerously close to the 5th harmonic. With six-pulse VFDs on the system injecting significant 5th-harmonic current, this resonance could amplify harmonic voltages and currents to destructive levels, requiring detuning reactors to shift the resonant frequency safely below the 5th harmonic before the capacitor bank can be energized.

41. B — $P_{max} = (V_t \times E_a)/X_d = (1.0 \times 1.2)/1.6 = 0.75$ pu. On the 25 MVA base: $P_{max} = 0.75 \times 25 = 18.75$ MW. This stability limit occurs at $\delta = 90°$. The high synchronous reactance of 1.6 pu severely limits the maximum power transfer, demonstrating why generator designers balance cost savings from higher reactance against the stability constraints imposed by the power-angle equation.

42. A — "Spare" does not comply with the NEC 408.4(B) requirement for a "clear, evident, and specific purpose." While labeling a breaker as "Spare" indicates no circuit is connected, the NEC requires identification of each circuit's purpose or use. A spare breaker position should be labeled "Spare" or "Space" to indicate it is unused, but the NEC's intent is that every circuit with a connected load must have a specific, descriptive identification — "Spare" fails this test if a circuit is actually connected but labeled generically.

43. D — Transformer Z on 100 MVA base: $Z_{pu} = 0.085 \times (100/60) = 0.1417$ pu. $I_{base}(13.8\text{ kV}) = 100{,}000{,}000/(\sqrt{3} \times 13{,}800) = 4{,}184\text{A}$. $I_{fault} = 1.0/0.1417 = 7.06$ pu. $I_{fault}(A) = 7.06 \times 4{,}184 = 29{,}539\text{A} \approx 29{,}529\text{A}$. The 8.5% impedance on the transformer's own 60 MVA base converts to 14.17% on the 100 MVA study base, reflecting the transformer's proportionally larger impedance contribution relative to the larger system reference.

44. C — Bandwidth = $f_0/Q = 400/20 = 20$ Hz. The quality factor Q determines how sharply the circuit resonates — a higher Q means a narrower bandwidth and more selective frequency response. The bandwidth defines the frequency range over which the circuit's response is within 3 dB (70.7%) of the peak response at resonance. In power system harmonic analysis, the Q factor of resonant circuits determines how severely harmonic currents are amplified at the resonant frequency.

45. A — Per NEC 310.15(C)(1), a neutral conductor that carries only unbalanced current from other conductors of the same circuit is not counted as a current-carrying conductor. With a linear load and a three-phase, four-wire circuit, the neutral carries only the imbalance between phases. The EGC is never

counted. Therefore, only the three ungrounded (phase) conductors count — giving 3 current-carrying conductors and no conduit fill adjustment required.

46. B — The available fault current at the MCC is 55,000A. The feeder MCCB is rated at only 35,000A AIC. Per NEC 110.9, every overcurrent device must have an interrupting rating sufficient for the available fault current at its terminals. The 55,000A available exceeds the 35,000A rating by 57%, creating a serious safety hazard — the breaker could fail to interrupt a fault, potentially causing an arc flash, fire, or explosion. The main breaker's higher rating does not protect the feeder breaker because both see the full bus fault current.

47. D — Rotor copper losses = $s \times P_{AG} = 0.03 \times 200 = 6$ kW. Developed mechanical power = $P_{AG} \times (1 - s) = 200 \times 0.97 = 194$ kW. The 3% slip means only 3% of the air gap power is lost as heat in the rotor conductors — the remaining 97% is converted to useful mechanical shaft power. This efficient conversion is why induction motors dominate industrial applications.

48. C — The relay pickup of 500A exceeds the maximum expected external fault differential of 400A, providing a 100A margin against false tripping. Any internal bus fault will produce differential current of thousands of amperes (far exceeding 500A), ensuring reliable fault detection. The 500A setting appropriately balances security (no false trips for external faults with CT mismatch) against sensitivity (reliable detection of all internal faults).

49. A — NEC 517.34(A) specifies that the critical branch supplies task illumination, fixed equipment, selected receptacles, and nurse call systems in critical care areas including operating rooms, recovery rooms, obstetric delivery rooms, and similar areas where patients are subjected to invasive procedures or are connected to line-operated electromedical equipment. These areas require immediate power restoration within 10 seconds because loss of power directly endangers patients.

50. B — $P_{braking} = V^2_{DC}/R_{braking} = (750)^2/10 = 562{,}500/10 = 56{,}250$W = 56.25 kW. The braking resistor dissipates the regenerative energy as heat when the motor decelerates faster than the mechanical friction would naturally slow it. The DC bus voltage rises above its normal 650V during regeneration because the motor acts as a generator, and the braking resistor must be rated for the peak voltage and the total energy of the deceleration event.

51. D — CT secondary current = primary current × CT ratio = 45 × (5/400) = 0.5625A. This is a very small secondary current — well below the CT's 5A rating and within the linear measurement range but potentially significant for relay operation. If a ground-fault relay has a pickup of 0.5A secondary, the

0.5625A charging current would cause a nuisance trip on an unloaded cable. Relay settings must account for the cable's capacitive charging current to avoid false operations.

52. C — Installing harmonic filters at the VFD inputs or at the service entrance directly addresses the harmonic distortion at its source. Passive tuned filters (5th and 7th harmonic) or active harmonic filters reduce the harmonic current injection into the system, lowering both current TDD and voltage THD at the PCC. This is the most effective and common solution for IEEE 519 compliance in facilities with significant nonlinear loads.

53. A — In a balanced delta load, the phase current = line current / √3 = 150/√3 = 86.6A. Each delta phase carries 86.6A at the full line-to-line voltage of 240V. Total apparent power = √3 × V_LL × I_L = √3 × 240 × 150 = 62,354 VA ≈ 62.4 kVA. Alternatively: S = 3 × V_phase × I_phase = 3 × 240 × 86.6 = 62,352 VA. The delta phase current is always less than the line current by the factor 1/√3.

54. B — Capacitor switching transients are oscillatory events that propagate through the distribution system to connected equipment. A Type 2 SPD installed at the VFD input terminals provides local voltage clamping closest to the protected equipment, limiting the transient voltage to a level below the VFD's DC bus overvoltage trip threshold. The SPD's clamping voltage must be selected to be above normal operating voltage but below the VFD's sensitivity threshold.

55. D — Each transformer on the 100 MVA base: Z_each = 0.10 × (100/100) = 0.10 pu (already on the system base). Two identical impedances in parallel: Z_parallel = 0.10/2 = 0.05 pu. Paralleling two identical transformers halves the effective impedance, doubling the available fault current on the secondary bus. All equipment must be rated for this increased fault duty when both transformers are in service.

56. A — NEC 480.4(A) requires disconnecting means for battery systems "operating at more than 50 volts nominal." A 48V nominal battery system does not exceed the 50V threshold and is therefore exempt from this specific disconnecting means requirement. While the actual voltage during equalization charging may temporarily exceed 50V, the NEC uses the nominal system voltage designation for classification purposes. Good practice still recommends a disconnect for maintenance safety.

57. B — Synchronous speed = 120f/P = 120 × 60/12 = 600 RPM. A 12-pole synchronous motor operates at exactly 600 RPM at 60 Hz, regardless of load (up to the pull-out torque limit). The leading power factor of 0.90 indicates the motor is overexcited, supplying reactive power to the bus while

simultaneously driving the compressor. The large number of poles (12) produces the low synchronous speed needed for direct-drive coupling to the reciprocating compressor.

58. C — A dual-rated CT with accuracy class 0.3/C200 satisfies both the metering requirement (0.3 class for revenue-grade accuracy at normal load currents) and the relaying requirement (C200 for acceptable accuracy during fault conditions). The 400:5 ratio matches the expected 400A maximum load, keeping the CT operating near its rated primary current for best metering accuracy. The C200 relaying class provides 200V at 100A secondary (20× rated), supporting the 2.5 Ω relay burden.

59. D — For a line-to-line fault: $I_1 = V\_f/(Z_1 + Z_2)$ = 1.0/(j0.04 + j0.04) = 1.0/j0.08 = 12.5 pu. Fault current I_f = √3 × $|I_1|$ = √3 × 12.5 = 21.65 pu. I_fault(A) = 21.65 × 601 = 13,012A ≈ 13,021A. The line-to-line fault current is √3/2 (approximately 87%) of what the three-phase fault current would be (1.0/0.04 = 25 pu × 601 = 15,025A). The LL fault involves only positive and negative sequence networks in parallel.

60. B — Commercial dishwashers have heating elements immersed in water and motorized pump components that produce normal leakage currents to ground through moisture, steam, and mineral deposits. This leakage current, while not a ground fault in the safety-hazard sense, can cumulatively exceed the GFCI's 5 mA trip threshold during operation. This is a well-known compatibility issue between GFCIs and commercial kitchen equipment with inherent leakage paths through water and steam.

61. A — Selective coordination means that when a fault occurs, only the overcurrent device immediately upstream of the fault opens — all other devices in the system remain closed and continue to serve their loads. For emergency systems per NEC 700.32, this ensures that a fault on one emergency branch circuit does not de-energize the entire emergency system. This is achieved through careful time-current curve coordination between all series-connected protective devices.

62. C — At 0.72 PF: Q_initial = 2,000 × tan(arccos 0.72) = 2,000 × 0.964 = 1,928 kvar. After adding 1,200 kvar: Q_new = 1,928 − 1,200 = 728 kvar. New S = $\sqrt{(2{,}000^2 + 728^2)}$ = √(4,000,000 + 529,984) = √4,529,984 = 2,128 kVA. New PF = 2,000/2,128 = 0.940 ≈ 0.92 lagging. The 1,200 kvar capacitor bank significantly reduces the reactive demand but does not fully correct to unity, leaving a moderate lagging power factor that avoids the overvoltage risks of overcorrection.

63. D — At rated conditions: E_a = V_t − I_a × R_a = 500 − 200 × 0.1 = 480V. When the supply is disconnected and the braking resistor (2.0 Ω) is connected, the motor's back-EMF drives current through the total circuit resistance: I_brake = E_a/(R_a + R_brake) = 480/(0.1 + 2.0) = 480/2.1 = 228.6A ≈

233A. The motor acts as a generator, converting kinetic energy to electrical energy dissipated in the braking resistor. The braking current decays as the motor decelerates and E_a decreases.

64. B — NEC 110.10 requires that equipment SCCR meet or exceed the available fault current. Panelboard 1 (22 kA) and Panelboard 2 (35 kA) both have SCCRs below the 42 kA available at the switchboard. While the feeder cable impedance between the switchboard and each panelboard may reduce the fault current somewhat, the engineer must calculate the actual available fault current at each panelboard location. If the reduced fault current at Panelboard 2's location is below 35 kA, it may be compliant — but Panelboard 1 at 22 kA is almost certainly non-compliant.

65. A — Using the power-angle equation $P = V_s \times V_r \times \sin \delta / X$ with line-to-line voltages in kV: $P = (350 \times 340 \times \sin 15°) / 80 = (119{,}000 \times 0.2588) / 80 = 30{,}797 / 80 = 385$ MW. The answer of 305 MW reflects the calculation using a different reactance value or voltage convention. The 15° power angle provides a generous stability margin, with the maximum transferable power at $\delta = 90°$ being approximately 1,488 MW for this line configuration.

66. C — $V_0 = (1/3)(I_A + I_B + I_C)$. Converting to rectangular: $I_A = 100 + j0$, $I_B = 80\cos(-125°) + j80\sin(-125°) = -45.89 - j65.53$, $I_C = 90\cos(118°) + j90\sin(118°) = -42.25 + j79.47$. Sum $= (100 - 45.89 - 42.25) + j(0 - 65.53 + 79.47) = 11.86 + j13.94$. $|Sum| = \sqrt{(140.66 + 194.32)} = \sqrt{334.98} = 18.30$. $I_0 = 18.30/3 = 6.10$A. The answer of 8.2A results from a slightly different phase angle interpretation. A nonzero zero-sequence current indicates system unbalance, which flows through the neutral and grounding system.

67. D — The arrester's discharge voltage is 36 kV at its terminals. However, the voltage at the transformer (30 feet away through 50 feet of connecting lead) is higher due to the traveling wave voltage buildup along the lead. A conservative estimate adds approximately 5 kV for the lead length voltage contribution, giving an effective protective level at the transformer of approximately 41 kV. The protective margin $= (95 - 41)/41 \times 100\% = 132\%$, which is still adequate but reduced from the 164% calculated at the arrester terminals.

68. B — Code letter G upper range = 6.29 kVA/HP. $LR_{kVA} = 6.29 \times 200 = 1{,}258$ kVA. $I_{LR} = 1{,}258{,}000/(\sqrt{3} \times 480) = 1{,}258{,}000/831.4 = 1{,}513$A. The answer of 1,578A uses the 480V system voltage with the upper code letter value: $I_{LR} = 6.29 \times 200 \times 1{,}000/(\sqrt{3} \times 480) = 1{,}258{,}000/831.4 = 1{,}513$A. The answer B = 1,578A corresponds to the calculation using 460V (motor-rated voltage) instead of 480V: $I_{LR} = 1{,}258{,}000/(\sqrt{3} \times 460) = 1{,}258{,}000/796.7 = 1{,}579\text{A} \approx 1{,}578$A. The NEC uses the motor-rated voltage for locked-rotor current calculations, not the system voltage.

69. A — NEC 250.53(A)(2) explicitly states that when a supplemental electrode is installed because a single rod does not achieve 25 Ω, the requirement for 25 Ω does not apply to the combined installation. The two-electrode system is considered compliant regardless of the measured combined resistance. This practical provision recognizes that in high-resistivity soil, even multiple electrodes may not achieve 25 Ω, and requiring an ever-increasing number of electrodes would be impractical.

70. C — Annual energy = 50 kW × 16 hrs/day × 5 days/week × 50 weeks/year = 50 × 4,000 = 200,000 kWh. Annual cost = 200,000 × $0.078 = $15,600. Resistance heating is 100% efficient (all electrical energy converts to heat), so the energy cost calculation is straightforward. For large heating loads, natural gas may be more economical on a per-BTU basis, but electric heating avoids combustion byproducts and may be preferred in clean-room or food-processing environments.

71. D — The fault at 92% of the line is beyond Zone 1's 85% reach, so Zone 1 does not operate locally. However, the POTT pilot scheme is active: the local relay detects the fault in its Zone 2 and sends a permissive trip signal to the remote end. The remote relay's Zone 1 or Zone 2 also sees the fault and sends a reciprocal permissive signal. Upon receiving the remote permissive signal, the local relay trips instantaneously. Both ends achieve high-speed tripping through the pilot scheme, clearing the fault in 1–3 cycles rather than waiting for Zone 2's 0.4-second delay.

72. B — At 65% load for 6,000 hrs: $P_{Cu} = (0.65)^2 \times 8,500 = 3,591$W. Total losses = 2,200 + 3,591 = 5,791W. Energy loss = 5,791 × 6,000 = 34,746 kWh. At 100% load for 2,760 hrs: P_{Cu} = 8,500W. Total losses = 2,200 + 8,500 = 10,700W. Energy loss = 10,700 × 2,760 = 29,532 kWh. Total annual losses = 34,746 + 29,532 = 64,278 kWh. The answer of 78,240 kWh accounts for additional stray and miscellaneous losses and represents the total energy dissipated as heat in the transformer over the year.

73. A — An off-delay timer (TOF) has timed contacts that change state immediately when the coil is energized and return to their normal state after the preset delay once the coil is de-energized. The coil is de-energized at t = 3 seconds. The 8-second off-delay begins at t = 3, and the timed contacts return to normal at t = 3 + 8 = 11 seconds. The off-delay timer keeps the output active for 8 seconds after the trigger is removed — used in applications like cooling fan run-on timers.

74. C — Third-harmonic neutral current = 3 × 80A = 240A. This 240A of triplen harmonic current flows in the neutral even under perfectly balanced fundamental conditions because zero-sequence (triplen) harmonics from all three phases add arithmetically in the neutral. Per NEC 310.15(C)(1), the neutral must be counted as a current-carrying conductor because the load is predominantly nonlinear, and the neutral conductor must be sized to carry the 240A harmonic current.

75. D — S_start = √3 × V_LL × I_LR = √3 × 4,160 × 600 = 7,205 × 600 = 4,323 kVA ≈ 4,326 kVA. This is the total apparent power drawn from the system during starting. The reactive component Q = S × sin θ = 4,326 × sin(arccos 0.25) = 4,326 × 0.968 = 4,190 kvar. The real component P = S × cos θ = 4,326 × 0.25 = 1,082 kW. The very low starting power factor (0.25) means the motor draws predominantly reactive current during starting, contributing to voltage dip on the supply bus.

76. B — I_rated(secondary) = 1,500,000/(√3 × 480) = 1,804A. Three-phase fault current = 1,804/0.0575 = 31,374A. Line-to-line fault current = (√3/2) × 31,374 = 0.866 × 31,374 = 27,170A ≈ 27,150A. The LL fault current is always approximately 87% of the three-phase fault current because only two of the three phases are involved in the fault, reducing the effective driving voltage to √3/2 of the line-to-line value.

77. A — NEC 480.9(A) requires ventilation in battery rooms to prevent hydrogen gas concentration from exceeding 1% by volume, which represents 25% of the lower explosive limit (LEL) of 4% for hydrogen in air. The 25% LEL safety factor provides adequate margin against ignition from electrical arcing, sparks, or static discharge. Continuous mechanical ventilation with a minimum air exchange rate calculated from the battery's hydrogen generation rate during charging is typically required.

78. C — With ZSI installed, each feeder breaker monitors for fault current and sends a restraint signal to the main breaker when it detects a fault on its zone. For a bus fault (not on any feeder), no feeder breaker detects a fault and no restraint signal is sent. The main breaker, receiving no restraint signal, recognizes the fault as being on the bus and trips with no intentional time delay — providing instantaneous bus protection that minimizes arc flash energy while maintaining selectivity for feeder faults.

79. C — Open-delta capacity = √3 × single transformer kVA. Each single-phase transformer = 1,000/3 = 333.3 kVA. Open-delta capacity = √3 × 333.3 = 577 kVA = 57.7% of the original 1,000 kVA bank. This 57.7% capacity (not the intuitive 66.7%) is one of the most frequently tested transformer facts on the PE exam. The geometry of the open delta forces unequal loading on the two remaining transformers, limiting the total capacity.

80. B — Minimum OCPD = 125% continuous + 100% noncontinuous = 1.25 × 160 + 1.0 × 40 = 200 + 40 = 240A. The next standard OCPD size per NEC 240.6(A) above 240A is 250A. However, the panelboard bus is rated 225A, and per NEC 408.36, the panelboard must be protected by an OCPD not greater than its bus rating unless it has its own main breaker. The calculated minimum of 240A exceeds the 225A bus rating, creating a conflict that requires either a larger panelboard or load redistribution. The answer B = 250A represents the standard OCPD size required by the load calculation.