CHAPTER 6

115. For maximum power transfer, the impedance of the load after transformation should be the same as the impedance of the source. For an ideal transformer, $\frac{Z_1}{Z_2} = \left(\frac{N_1}{N_2}\right)^2$

$$\frac{N_1}{N_2} = \sqrt{\frac{Z_1}{Z_2}} = \sqrt{\frac{90}{15}} = \sqrt{6} = 2.449$$

THE CORRECT ANSWER IS: (B)

138. The line voltages on the high and low sides are 115 kV and 24 kV respectively. Because of the connection, the phase voltage on the high side is 115 kV, and the phase voltage on the low side is 24 kV/1.732 = 13.86 kV.

The turns ratio is 115/13.86 = 8.3

THE CORRECT ANSWER IS: (C)

140. $Z_{high} = \left(\frac{N_{high}}{N_{low}}\right)^2 Z_{low} = \left(\frac{2}{1}\right)^2 (4\angle 30°) = 16\angle 30°\ \Omega$

THE CORRECT ANSWER IS: (D)

501. $I_{primary}$ = 5 A × (400 turns/5 turns) = 400 A

THE CORRECT ANSWER IS: (C)

502. The circuit would need to be balanced out to account for the 30° phase shift between wye and delta windings and, also, for the turns ratio of the transformer. Otherwise, there would be a non-zero current through the relay restraint windings during non-fault conditions. Answer (A).

The idea that CTs must be physically wired to maintain some arbitrary terminal nomenclature seems nonsensical; thus, eliminate (B).

The American standard is, indeed, to label the high-side terminal H_1 and the low-side terminal X_1 such that voltage H_1-neutral leads X_1-neutral by 30°, and the phase shift will be 30°, not more than 30°. But no matter how the CTs are connected, it will not affect the phasing of the transformer windings themselves; thus, eliminate (C).

There is no reason why a delta winding must be on either the low or high side of a transformer; thus, eliminate (D).

THE CORRECT ANSWER IS: (A)

525. The transformers will load in inverse proportion to their impedances.

Converting T_1 impedance to T_2 Base: $j0.045\left(\frac{2{,}000}{1{,}000}\right) = j0.09$

$$\frac{\text{Load}_{T_1}}{\text{Load}_{T_2}} = \frac{Z_{T_2}}{Z_{T_1}}$$

When T_1 is fully loaded to 1,000 kVA,

$$\text{Load}_{T_2} = (1{,}000)\left(\frac{0.09}{0.06}\right) = 1{,}500 \text{ kVA}$$

Total Load = 1,500 + 1,000 = 2,500 kVA

THE CORRECT ANSWER IS: (B)

526. If the transformers are paralleled, the voltages of the secondary windings will be 30° out of phase, resulting in excessive circulating currents. Changing the turn ratios of the transformers or reconfiguring the neutral connections will not affect the 30° phase shift between the secondary winding voltages. Thus transformers should not be paralleled.

THE CORRECT ANSWER IS: (A)

CHAPTER 7

520. $\text{Reg} = (\eta_{NL} - \eta_{FL}) \times 100 / \eta_{FL} = (1{,}790 - 1{,}750) \times 100 / 1{,}750 = 2.3\%$

THE CORRECT ANSWER IS: (B)

CHAPTER 8

518. $I_G = \frac{132}{13.2} I_L = 10\, I_L = 10 \times 75.93 = 759.3 \text{ A}$

THE CORRECT ANSWER IS: (A)

521. $\text{Generator } I_{out} = \frac{1{,}131 \text{ kVA}}{(2.4 \text{ kV})(\sqrt{3})} = 272 \text{ A}$

THE CORRECT ANSWER IS: (B)

522. $\text{Generator Power}_{out} = (150 \text{ MVA})(0.85) = 127.5 \text{ MW}$

THE CORRECT ANSWER IS: (C)

CHAPTER 9

134. $S_{motor} = \sqrt{3} V_l I_l \angle \cos^{-1}(pf) = \sqrt{3}(480)(34)\angle \cos^{-1}(0.75) = 28.3\angle 41.4° \text{ kVA}$

$$\begin{aligned}
Q_{new} &= P[\tan(\cos^{-1}\theta)] \\
&= 21.7[\tan(\cos^{-1} 0.9)] = 10.3 \\
Q_{new} &= Q_{old} + Q_{add} \\
Q_{add} &= Q_{new} - Q_{old} = 10.3 - 18.7 \\
&= -8.4 \text{ kvar}
\end{aligned}$$

THE CORRECT ANSWER IS: (C)

139. Synchronous speed is given by 120 f/P, where f is the frequency (Hz) and P is the total number of poles. An induction motor will slip slightly when operating under load. Therefore it will run at a speed slightly less than synchronous. The synchronous speed just above 1,600 rpm that corresponds to 60 Hz and an even number of poles is 1,800 rpm. This implies that the number of poles is four.

THE CORRECT ANSWER IS: (B)

519. Note that only the mechanical motor properties are relevant to the question, not the electrical properties. The following equation relates motor speed, torque, speed, and shaft horsepower:

hp = torque (ft-lb) × speed (rpm) × (hp/33,000 ft-lb/min) × (2π rad/rev)

Solving for full-load torque:

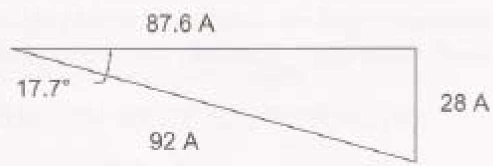
$$T_{FL} = 1{,}000 \text{ hp} \times 33{,}000 \text{ ft-lb/min-hp} / (1{,}165 \text{ rpm} \times 2\pi \text{ rad/rev})$$

$$= 4{,}508 \text{ ft-lb}$$

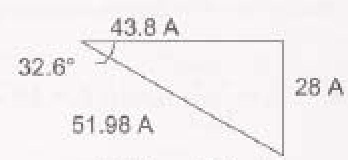
$$T_{START} = 150\%\ T_{FL} = 1.5 \times 4{,}508 = 6{,}762 \text{ ft-lb}$$

THE CORRECT ANSWER IS: (D)

523. At no load, the current is mostly reactive. Thus, reactive motor current at no load = 28 A and is nearly independent of motor load.



Full-Load Conditions



Half-Load Conditions

Real current at full load = 87.6 A. See full-load phasor diagram above.

At half load, the real current is 50% of 87.6 = 43.8 A, the power factor angle = 32.6°.

Power factor at half load = cos 32.6° = 0.84

THE CORRECT ANSWER IS: (D)

524. The wye-start, delta-run design feature reduces the starting voltage to the motor and hence its starting current. Answer (D).

High-efficiency motors tend to have larger wire, more iron, and thinner laminations to reduce the internal impedance of the motor. This may increase starting current. Eliminate (A).

Locked-rotor current is not a function of load; however, starting a motor under loaded conditions can increase the time it takes it to reach its operating speed and cause its start-up temperature to rise. Eliminate (B).

A higher service factor is a measure of the overload capability of the motor and is not related to starting current. Eliminate (C).

THE CORRECT ANSWER IS: (D)

531. The vars vary as the square of the applied voltage.

$$\text{kvar} = \left(\frac{208}{240}\right)^2 (110) = 82.6$$

THE CORRECT ANSWER IS: (A)

528. A 3-phase induction motor in which the inverter allows the voltage-to-frequency ratio to increase may saturate. Answer (B).

Operating a 50-Hz transformer at higher than rated frequency will reduce the chances of saturating the transformer. Eliminate (A).

Geomagnetic storms do not cause saturation in delta transformers since the delta is not referenced to ground. Eliminate (C).

The normal current transformer configuration is with a short-circuited secondary winding. Opening the secondary circuit could cause saturation. Eliminate (D).

THE CORRECT ANSWER IS: (B)

CHAPTER 11

117. Two *AND* gates into an *OR* gate yields
$AB + CB = B(A+C)$

THE CORRECT ANSWER IS: (A)

513. Since the power supply is loaded, there must be nonzero charging current being supplied to the capacitor. It is reasonable to assume steady-state conditions. It is also reasonable to assume that the forward voltage drop across the diodes is negligible compared to 120 V and that the conductance of the diodes is zero when reverse biased.

Sketch the current for one ac phase. The single-phase neutral current will consist of one positive pulse and one negative pulse, per 1/60-second cycle, when the ac voltage exceeds the dc voltage on the filter capacitor and the capacitor is charging. Each of the other two ac phases will contribute similar current pulses on the neutral, shifted by 120° and 240° (1/180 and 2/180 seconds), respectively. The pulses will not cancel; the primary frequency on the neutral will be the first triplen, i.e., 180 Hz. (Other, higher, triplen harmonics will also be present.) Answer (A).

(B) shows the correct number of current pulses per cycle, but they do not alternate, therefore, eliminate (B).

(C) shows only three pulses per cycle, each of the same polarity, therefore, eliminate (C).

(D) a flat trace, i.e., zero neutral current, would occur if there were no charging current being supplied to the capacitor; since the power supplies are resistively loaded, the charging current must be nonzero, therefore, eliminate (D).

THE CORRECT ANSWER IS: (A)

514. This inverter essentially produces 3-phase square waves by sequentially switching the transistors on and off to drive the motor. For the purpose of this question, it is reasonable to neglect the forward voltage drop across the transistors when they are conducting.

Pick any two transistors that are connected to opposite sides of the dc link and to different motor phases. Assume these two transistors are turned on. The phase-to-phase voltage across those two motor phases is equal to the dc-link voltage.

THE CORRECT ANSWER IS: (D)

515. $I_{AVE} = \frac{1}{T}\int_0^T i(t)dt$, where T is the period of the waveform, 180°

$$= \frac{1}{\pi}\int_{45^\circ}^{180^\circ} \sin(\phi)d\phi$$

$$= -\frac{1}{\pi}\cos(\phi)\Big|_{45^\circ}^{180^\circ}$$

$$= 0.543 \text{ A}$$