1. a.

KCL at $X$:

\[
\frac{14 - V_X}{7} - \frac{V_X}{42} + 1 + \frac{V_Y - V_X}{17} = 0
\]

KCL at $Y$:

\[
\frac{V_X - V_Y}{17} + \frac{12 - V_Y}{12} + \frac{25 - V_Y}{5} = 0
\]

1. b.

Equations in standard form:

\[-\frac{23}{102} V_X + \frac{1}{17} V_Y = -3\]

\[\frac{1}{17} V_X - \frac{20}{51} V_Y = -6\]

$\Delta = 13/153$. Then

\[V_X = \frac{1}{\Delta} \det \begin{bmatrix} -3 & 1/17 \\ -6 & -20/51 \end{bmatrix} = 18 V\]

and

\[V_Y = \frac{1}{\Delta} \det \begin{bmatrix} -23/102 & -3 \\ 1/17 & -6 \end{bmatrix} = 18 V\].
1. c.

Box at left: $I_{SC} = 3 A, R_T = 7 \parallel 42 = 6 \, \Omega$, $V_{OC} = 3 \cdot 6 = 18 \, V$

Box at right: $I_{SC} = 6 A, R_T = 5 \parallel 12 \parallel 20 = 3 \, \Omega$, $V_{OC} = 6 \cdot 3 = 18 \, V$

Thevenin Equivalents: A

![Thevenin Equivalents Diagram]

1. d.

Replacing boxes with Thevenin equivalents gives the above figure.

$I_{xy} = 0 \, A$ and then $V_X = 18 \, V, \quad V_Y = 18 \, V$

2. a.

First note that $V_{R1} = V_{in}(-) = V_{in}(+) \text{ by the ideal op-amp rules and that } I_{in}(-) = 0$. Then $I_1 = V_{R1}/R_1 = 1/50 = 20 \, mARMS$
2. b.
Voltage across $R_1 = 1 VRMS$ as outlined above.

2. c.
Ideal transformer has $V_1/V_2 = N_1/N_2$; thus $V_{out} = 5 VRMS$

2. d.
Ideal transformer has $P_{in} = P_{out}$; therefore, $P_{out (op-amp)} = 1^2/50 = 20 mW$

3. a.
$A = B = 0$ means no base current in $Q_1$ and $Q_4$ and therefore they are cut-off. if $X$ is high then $Q_3$ is on and gate of $Q_2$ is low. $Q_2$ and $Q_3$ are in a symmetrical arrangement, so that $Y = X$

3. b.
When $(A, B) = (0, 1)$ then $Q_2$ is off and $Q_1$ is cutoff, so $X = 10.0 V$. Then $Q_3$ is on, so that it lowers the voltage at Y to $0.0 V$. $(A, B) = (1, 0)$ similarly gives $(X, Y) = (0.0 V, 10.0 V)$.

3. c.
This is a S-R flip-flop which has TTL-level inputs and CMOS-level outputs.

3. d.
When $A = B = 1$ then both MOSFETs are off and the voltages at $X$ and $Y$ remain at the BJT saturation voltage. $(X, Y) = (0.3 V, 0.3 V)$.

4. a.
With the compensating capacitors in place, $P_{active} = \sqrt{3}V_{line}I_{\phi} = 9.145 kW$
4. b.
An additional current of \(- j \omega CV_{\text{line}}\) flows in each \(\Delta\) phase if the capacitors are removed. This corresponds to an additional current of \(\sqrt{3} \cdot j34.47 \text{ARMS}\) in each phase. Then the total current in each phase is \(|11 - j34.47| = 36.19 \text{ARMS}|\).

4. c.
The apparent power is then \(\sqrt{3} V_{\text{line}} I_{\phi} = 30.088 \text{ kVA}\).

4. d.
Phase angle\(= \arctan(I_{m}(I)/R_{e}(I)) = \arctan(-34.47/11) = -72.23^\circ\).
Negative sign indicates current is lagging.

5. a.
\[n = \frac{2f(1-s)}{p} = (1/2)(60)(60)(0.97) = 1746 \text{ RPM}\]

5. b.
\[|Z_{\text{tot}}| = \sqrt{(X')^2 + (R' + (R''(1-s))/s))^2} = 20.216 \Omega.\] Then \(I_m = 208/20.216 = 10.28896 \text{ ARMS}\) and then \(P_{\text{mech}} = 3I_m^2 \cdot (R''(1-s)/s) = 6.1612 \text{ kW}\) or \(8.259 \text{ hp}\).

5. c.
\[T = P_{\text{mech}}/\Omega = P_{\text{mech}}/(2 \pi \cdot 1746/60) = 33.697 \text{ nt - m}\]

5. d.
At startup, \(|Z_m| = \sqrt{(X')^2 + (R')^2} = 1.1314 \Omega\) and thus \(I_m = 208/|Z_m| = 183.847 \text{ ARMS}\). Then
\[T_{\text{start}} = \lim_{\Omega \to 0} \frac{P}{\Omega} = \frac{3I_m^2 R''p}{4\pi f}\]
\[= 322.7662 \text{ nt - m}\]
5. e.

\[ P_{\text{apparent}} \text{ at run} = 3V_{\text{line}}I_{\text{line}} = 3 \cdot 208 \cdot 10.28896 = 6.4203 \text{ kVA} \]

so “apparent” efficiency is \[ P_{\text{mech}}/P_{\text{apparent}} = 95.64 \% \].

6. a.

\[ jX_sI \]

\[ e \]

\[ \delta \]

\[ \theta \]

\[ v \]

Note that \( v \) makes a fifteen degree angle with the horizontal and therefore \( e \) is at 45° to the horizontal. Thus the angle between \( +jX_sI \) and \( v \) is 15° + 90° = 105°.

6. b.

By law of sines, \[ |jX_sI|/\sin \delta = |e|/\sin 105^\circ = |v|/\sin 45^\circ. \]

So \[ |jX_sI| = |v| \cdot \sin 30^\circ / \sin 45^\circ = 2545.6 \text{ VRMS}. \]

The current in each phase is \[ I = P_{\text{apparent}}/(3V) = 101.85 \text{ kA}, \text{ so } X_s = 2546/101850 = 0.025 \Omega \].

Note that the active power is

\[ P_{\text{active}} = P_{\text{apparent}} \cos \theta = \frac{3|v||e|\sin \delta}{X_s} \]

and \( P_{\text{active}} = 1100 \cos \theta = 1062.5 \text{ MW}. \)
6. c.

The excitation $e$ has a magnitude of $|v| \sin 105^\circ / \sin 45^\circ = \boxed{4917.7 \text{ VRMS}}$ and the phase is $180^\circ + 45^\circ = \boxed{225^\circ}$. Note that the active power is $3|v||e| \sin \delta / X_s = 1062.5 \text{ MW}$ as outlined above.

6. d.

$$n_s = 3600 = \frac{2f}{p} \rightarrow p = 2 \text{ (2 poles)}$$

6. e.

$$I_\phi = 101.85 \text{ kA} \text{ as outlined above.}$$