APPENDIX D MAGNETIC SALIENCY AND THE GENERATOR TRANSIENT VOLTAGE

This appendix shows magnetic saliency affects the value the transient generator voltage has.

D.1 $|E_{KBG}|$ WHEN MAGNETIC SALIENCY IS CONSIDERED

The steady state operating point of the Koeberg generator of the improved two generator model shown in Chapter 3, figure 3.25 is $P = 450$ MW, $Q = 13.6$ MVAR and $|V_{KBG LV}| = 1.005$ per unit.

The q-axis synchronous reactance of the Koeberg machine, expressed on a 1072 MVA base, is $x_q = 2.28$ per unit.

The angle, $\delta$, between the generator q-axis and the terminal voltage can be computed using (Appendix F, equation F.7):

$$
\delta = \tan^{-1}\left(\frac{x_q P}{V^2 + x_q Q}\right)
$$

(D.1)

$\delta$ obtained for the Koeberg generator is:

$$
\delta = \tan^{-1}\left(\frac{x_q P}{V^2 + x_q Q}\right)
$$

$$
= \tan^{-1}\left[\frac{2.28 \times \frac{450}{1072}}{(1.005)^2 + 2.28 \times \frac{13.6}{1072}}\right]
$$

$$
= 42.65^\circ
$$

(D.2)

The d- and q-axis components of the terminal voltage, $V$, at Koeberg can be computed by using equation F.8. $V_d$ and $V_q$ are:
\[ V_d = V \sin(\delta) \]
\[ = 1.005 \sin(42.65^\circ) \]
\[ = 0.6809 \] (D.3-a)

\[ V_q = V \cos(\delta) \]
\[ = 1.005 \cos(42.65^\circ) \]
\[ = 0.7392 \] (D.3-b)

The \( d \)- and \( q \)-axis components of the stator current at Koeberg, expressed on a 1072 MVA base, are (Appendix F, equation F.16):

\[
I_d = \frac{-PV_d - QV_q}{-V_d^2 - V_q^2} = \frac{- \left( \frac{450}{1072} \right) \times 0.6809 - \left( \frac{13.6}{1072} \right) \times 0.7392}{- (0.6809)^2 - (0.7392)^2} = 0.2923 \text{ per unit; } S_{BASE} = 1072 \text{ MVA} \] (D.4-a)

\[
I_q = \frac{QV_d - PV_q}{-V_d^2 - V_q^2} = \frac{\left( \frac{13.6}{1072} \right) \times 0.6809 - \left( \frac{450}{1072} \right) \times 0.7392}{- (0.6809)^2 - (0.7392)^2} = 0.2987 \text{ per unit; } S_{BASE} = 1072 \text{ MVA} \] (D.4-b)

The \( d \)- and \( q \)-axis transient reactances of the Koeberg machine, expressed on a 1072 MVA base are \( x_d' = 0.395 \) per unit and \( x_q' = 0.689 \) per unit. Hence, the transient voltage of the Koeberg generator is (Appendix F, equation F.1):
\[ E'_{KBG} = \left( V_d - x'_d I_q \right) + j \left( V_q + x'_d I_d \right) \]

\[ = E'_d + j E'_q \]

\[ = (0.6809 - 0.689 \times 0.2987) + j (0.7392 + 0.395 \times 0.2923) \]

\[ = 0.4751 + j 0.8547 \]

\[ = 0.9778 \angle \left( 90^\circ - 60.93^\circ \right) \]

\[ = 0.9778 \angle 29.07^\circ \]

(D.5)

D.2 \[ |E'_{KBG}| \ \text{WHEN MAGNETIC SALIENCY IS NOT CONSIDERED} \]

For the case where the generator is modelled using the constant voltage behind transient reactance model \( E'_{KBG} \) can be computed using [1, 187]:

\[ E'_{KBG} = V + (R_a + j x'_i) I \]

(D.6)

\( R_a \) is very small and is usually neglected.

The constant voltage behind transient reactance generator model does not consider magnetic saliency.

When magnetic saliency is not modelled armature reaction, \( x'_i \), should be computed using [41, p84]:

\[ x'_i = \left( \frac{x'_d + x'_q}{2} \right) \]

(D.7-a)

For the Koeberg generator \( x'_i \), expressed on a 1072 MVA base, is:

\[ = \left( \frac{0.395 + 0.689}{2} \right) \]

\[ = 0.542 \]

(D.7-b)
Hence, $E'_{KBG}$ is:

\[
E'_{KBG} = V + j \frac{x_i}{V} S \sqrt{\left(\frac{450}{1072}\right)^2 + \left(\frac{13.6}{1072}\right)^2} \frac{1.005}{1.005}
\]

\[
= 1.005 + j \ 0.2265
\]

\[
|E'_{KBG}| = 1.03 \ \text{p.u.} \quad \text{(D.8)}
\]