<u>APPENDIX D</u> MAGNETIC SALIENCY AND THE GENERATOR TRANSIET VOLTAGE

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

D.1 $\left|E'_{KBG}\right|$ 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 $\left|V_{KBG\ LV}\right| = 1.005$ 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, δ, between the generator q-axis and the terminal voltage can be computed using (Appendix F, equation F.7):

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

δ obtained for the Koeberg generator is:

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

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

$$= 42.65^\circ \tag{D.2}$$

The d- and q-axis components of the terminal voltage, $\boldsymbol{V}$, at Koeberg can be computed by using equation F.8. V_d and V_q are:

$$V_d = V\sin(\delta)$$

$$= 1.005\sin(42.65^\circ)$$

$$= 0.6809 \quad \text{(D.3-a)}$$

$$V_q = V\cos(\delta)$$

$$= 1.005\cos(42.65^\circ)$$

$$= 0.7392 \quad \text{(D.3-b)}$$

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

$$I_d = \frac{-PV_d - QV_q}{-V_d^2 - V_q^2}$$

$$= \frac{-\left(\frac{450}{1072}\right)*0.6809 - \left(\frac{13.6}{1072}\right)*0.7392}{-(0.6809)^2 - (0.7392)^2}$$

$$= 0.2923 \text{ per unit; } S_{BASE} = 1072 \text{ MVA} \quad \text{(D.4-a)}$$

$$I_q = \frac{QV_d - PV_q}{-V_d^2 - V_q^2}$$

$$= \frac{\left(\frac{13.6}{1072}\right)*0.6809 - \left(\frac{450}{1072}\right)*0.7392}{-(0.6809)^2 - (0.7392)^2}$$

$$= 0.2987 \text{ per unit; } S_{BASE} = 1072 \text{ MVA} \quad \text{(D.4-b)}$$

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):

$$\boldsymbol{E}'_{KBG} = \left(V_d - x'_q I_q\right) + \boldsymbol{j}\left(V_q + x'_d I_d\right)$$

$$= E'_d + \boldsymbol{j}\, E'_q$$

$$= (0.6809 - 0.689 * 0.2987) + \boldsymbol{j}\,(0.7392 + 0.395 * 0.2923)$$

$$= 0.4751 + \boldsymbol{j}\, 0.8547$$

$$= 0.9778\angle\left(90^0 - 60.93^\circ\right)$$

$$= 0.9778\angle 29.07^\circ \tag{D.5}$$

D.2 $\left|\boldsymbol{E}'_{KBG}\right|$ WHEN MAGNETIC SALIENCY IS NOT CONSIDERED

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

$$\boldsymbol{E}'_{KBG} = V + (R_a + \boldsymbol{j}\, x'_i)\, I \tag{D.6}$$

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]:

$$x'_i = \left(\frac{x'_d + x'_q}{2}\right) \tag{D.7-a}$$

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

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

$$= 0.542 \tag{D.7-b}$$

Hence, $\boldsymbol{E}'_{\boldsymbol{KBG}}$ is:

$$\boldsymbol{E}'_{\boldsymbol{KBG}} = V + \boldsymbol{j}\ x'_i \frac{S}{V}$$

$$= 1.005 + \boldsymbol{j}\ 0.542 \frac{\sqrt{\left(\frac{450}{1072}\right)^2 + \left(\frac{13.6}{1072}\right)^2}}{1.005}$$

$$= 1.005 + \boldsymbol{j}\ 0.2265$$

$$\left|\boldsymbol{E}'_{\boldsymbol{KBG}}\right| = 1.03 \text{ p.u.} \tag{D.8}$$