APPENDIX B

KEY'S TEN STEP ALGORITHM [92]

The Key's ten Step algorithm employed to compute the minimum reactive power required at receiving end is given as follows:

Step 1: Compute, $P_{r\,(crit)} = E^2_S / X$

If $P°_r > P_{r\,(crit)}$ no solution exists

If $P°r \leq P_{r\,(crit)}$ then go to **Step 2**

Step 2: Compute, $P_{r(max)} = P°_r\,[\,100 / (\,100 - s.m_{des})]$

If $P_{r\,(max)} > P_{r\,(crit)}$ go to **Step 3**

If $P_{r\,(max)} \leq P_{r\,(crit)}$ go to **Step 4**

Step 3: Compute, $E°_r = E_s$

$$\delta°_r \quad = -\sin^{-1}(\,P°_r / P_{r\,(crit)}) \qquad \text{(B-1)}$$

$$s.m.° = (1 - P°_{r(crit)})100 \qquad \text{(B-2)}$$

$$Q_m \quad = P_{r(crit)}\,(1 - wxc)$$

(stop)

Step 4: Compute critical voltage ($E_{r(crit)}$ s.m.) of the line limited by stability margin,

$$E_{r(crit)s.m.} = [P^2_{r(max)}\,X^2 / E^2_s + E^2_s\ / 4\,[1 - wxc]^2\,]^{\,1/2}$$

If $E_{r(crit)s.m.} \geq E_s$ the line is stability limited with

$$Q_m = [E^2_r\,(1 - wxc) - F_sE_r\cos\delta_{r(max)}\,] / X$$

$E_{r\,(crit)} = E_s$ go to **Step 5**

If $\underline{E}_r < E_{r(crit)s.m.}$ the line is stability limited with

$E_{r(crit)} = E_{r(crit)s.m.}$ Go to **Step 6**

If $E_{r(crit)s.m.} \leq \underline{E}_r$ the line is voltage limited with

$E_{r\,(max)} = \underline{E}_r$ go to **Step 7**

Step 5: Computer $E°_r = E_s$

$\delta°_r$ = found from (B – 1)

$s.m.° = s.m._{des}$

$\delta_{r(crit)} = -\sin^{-1} (P_{r(max)} / P_{r(crit)})$

$\delta_m = P_{r(crit)} (1 - wxc - \cos \delta_{r(crit)})$

(stop)

Step 6: Compute $E_{r\,(max)} = E_{r(crit)s.m.}$

$\delta_{r(max)} = -\sin^{-1} [P_{r(max)} X / (E_{r(max)} E_s)]$

$s.m.° = s.m._{des}$

$Q_m = [E_{r(max)} (1\text{-}wxc) - E_s E_{r(max)} \cos \delta_{r(max)}] / X$

go to **Step 8**

Step 7 : Compute,

$\delta_{r\,(max)} = -\sin^{-1} (X\, P_{r(max)} / E_s\, \underline{E}_r)$

$\delta_{r(crit)} = -\cos^{-1} [E_s / (2E^2_s + 4Q_m\, x\, (1 - wxc))^{1/2}]$

$E_{r(crit)} = [E_s \cos\delta_{r(crit)} + E^2{}_S \cos^2 \delta_{r(crit)} + 4Q_m\, X\, (1 - wxc)\,] / 2(1\text{-}wxc)$

$P_{r(crit)} = (E_s\, E_{r(crit)}) / X + \cos\delta_{(\,r(crit)} + \theta) - (E^2{}_{r(crit)} \cos\theta) / X$

s.m.° = found from (B -2)

go to **Step 8**

Step 8: Compute the required angle and reactive power at receiving end :

$\delta^\circ_{r(req)}$ = found from (A – 1)

$Q^\circ_{r(req)} = P_{r(crit)}\ (1 - wxc - \cos \delta^\circ_{r(req)})$

If $Q^\circ_{r(req)} \leq Q_m$ go to **Step 9**

If $(Q^\circ_{r(req)} > Q_m$ go to **Step 10**

Step 9: Compute, $E^\circ_r = E_s$

δ°_r = found from (B – 1)

(stop)

Step 10: Compute,

$C_1 = E_s\,(Q^2_m + P^{\circ 2}_r)^{1/2}$

$C_2 = \tan^{-1}(P^\circ_r / Q_m)$

$C_3 = Q_m E^2_s - 2X(1 - wxc)P^{\circ 2}_r$

$\delta^\circ_r = ½\,(C_2 - \cos^{-1}(C_3/C_1))$

$E^\circ_r = XP^\circ_r / E_s \sin(-\delta^\circ_r)$

(stop)