APPENDIX-A

(A) Optimum Position of Series Capacitors:

When the line resistance is neglected, the stability limit is given by **[Fig. 5.3 (a)]**:

$P_{r(max)} = E_s E_r / B_0$

Where, $B_0 = Z_0 \sinh(\gamma \ell) - jX_c \cosh(\gamma x) \cosh(\gamma(\ell - x))$

$\gamma = \sqrt{ZY}$ = Propagation Constant

$Z_0 = \sqrt{Z/Y}$ = Surge Impedance

For Maximum Power Transfer,

$$d/dx\,(B_0) = d/dx\,[Z_0 \sinh(\gamma \ell) - jX_c \cosh(\gamma x) \cosh(\gamma(\ell - x))] = 0 \qquad \text{(A-1)}$$

$$\sinh(\gamma(\ell - 2x)) = 0 \qquad \text{(A-2)}$$

OR

$$x = \ell/2 \qquad \text{(A-3)}$$

This is the condition for the maximum power transfer, which speaks that the maximum power transfer will be, when, the capacitor is located at the mid-point of the line.

(B) Expression for Compensation Efficiency:

The expression for the compensation efficiency is derived for the typical case. The other expressions can be derived on similar lines.

(1) Without Shunt Compensation: Two Capacitor Banks:

When two equal capacitor banks are placed at one third distance along the line, the total line constants are given by:

$$\begin{bmatrix} A_0 & B_0 \\ C_0 & D_0 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} 1 & -JX_C/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} 1 & -jX_C/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} \quad \text{(A-4)}$$

Where, A, B, C and D are line constants for one third line length. The effective transfer impedance is:

$$B_0 = (A^2B + ABD + B^2C + D^2B) - jX_C (A^3 + ABC - j (X_CA^2C)/4) \quad \text{(A-5)}$$

The transfer impedance of uncompensated line is:

$$B' = B_0/X_C = 0 = A^2B + ABD + B^2C + D^2B \quad \text{(A-6)}$$

Hence the reduction in transfer impedance due to compensation is:

$$B' - B_0 = j X_C (A^3 + ABC - j A^2CX_C/4) \quad \text{(A-7)}$$

Compensation Efficiency,

$$\mathbf{K = Re (A^3 + ABC - j A^2CX_C/4)} \quad \text{(A-8)}$$

(2) With Shunt Compensation Single Capacitor Bank:-

When Series Capacitor and Shunt Reactor Banks are located at distance "X" from the Sending End, as shown in **Fig. 5.3(b)**, the total line constants are given by:

$$\begin{bmatrix} A_0 & B_0 \\ C_0 & D_0 \end{bmatrix} = \begin{bmatrix} A1 & B1 \\ C1 & D1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -jb/2 & 1 \end{bmatrix} \begin{bmatrix} 1 & -JX_C/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -jb/2 & 1 \end{bmatrix} \begin{bmatrix} A2 & B2 \\ C2 & D2 \end{bmatrix} \quad \text{(A-9)}$$

And the effective transfer impedance B_0 is:

$$B_0 = (A_1B_2 + B_1D_2) - j\ bB_1B_2 - j\ X_C\ (A_1 - jbB1/2)\ (D_2 - jbB_2/2) \qquad \text{(A-10)}$$

The reduction in transfer impedance is hence,

$$B_0|_{Xc=0} - B_0 = jX_C\ (A_1 - jbB1/2)\ (D_2 - jbB_2/2) + j\ bB_1B_2 \qquad \text{(A-11)}$$

And the Compensation Efficiency K is:

$$K = \mathbf{Re}\ [(A_1 - jbB1/2)\ (D_2 - jbB_2/2) + j\ bB_1B_2 / X_C] \qquad \text{(A-12)}$$