CHAPTER VII

OUTPUT

Power injection at a node may be found from the summation of current injected to that node.

$$S_m = V_m^* \times I_m$$

$$= V_m^* \times \sum_{n=1}^{k} V_n Y_{m,n}$$

$$IP+jIQ = \sum_{n=1}^{k} (VP(n)+jVQ(n)(A(m,n)+jB(m,n))$$

$$= \sum_{n=1}^{k} (VP(m)*A(m,n)-VQ(m).B(m,n)+j \sum_{n=1}^{k} (VP(n)*$$

$$B(m,n)+VQ(m).A/m,n) \qquad (7.1)$$

$$SP(m)+jSQ(m) = (VP(m)-jVQ(m))(IP+jIQ)$$

$$= (VP(m)\ IP+VQ(m).IQ)+j(VP(m).IQ-VQ(m)IP \qquad (7.2)$$

Power flow along the line.

Power flow through a transformer can be derived as follow

Current flowing from the transformer to busbar (B)

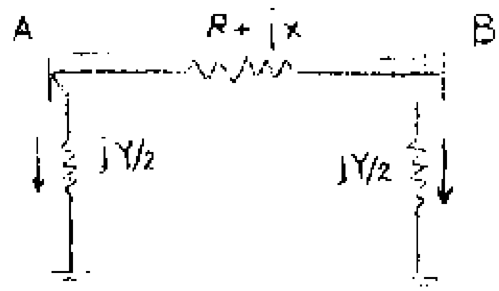

Fig. 20 Line Characteristics

$$I_B = -(nV_A - V_B).jB$$

$$= (V_B - nV_A).jB$$

$$= (1/n\ V_B - V_A).n.jB$$

$$S_{BA} = V_B^*(1/nV_B - V_A).n.jB \quad (7.3)$$

$$I_A = n(nV_A - V_B).jB$$

$$= (nV_A - V_B).n.jB$$

$$S_{AB} = V_A^*(nV_A - V_B)n.jB \quad (7.4)$$

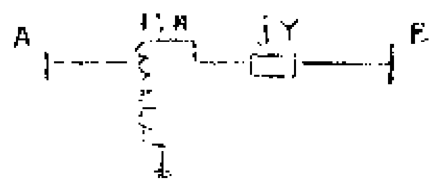

Fig. 21

Power flow through a transmission line can be derived as follow.

Current flowing through the mutual admittance.

$$I_A = (V_A - V_B)(A + jB)$$

$$S_{AB} = V_A^*(V_A - V_B)(A + jB)$$

$$= V_A^*.(V_A - V_B)A + V_A^*.(V_A - V_B).jB \quad (7.5)$$

$$I_B = (V_B - V_A)(A + jB)$$

$$S_{BA} = V_B^*(V_B - V_A)(A + jB)$$

$$= V_B^* . (V_B - V_A)A + V_B^*(V_B - V_A)jB \qquad (7.6)$$

Current flowing through a shunt admittance at busbar K

$$I_Y = V_K . jY/2$$

$$S_Y = V_K^* . V_K . jY/2$$

$$= V_K^2 . jY/2$$

Hence, Power flowing from busbar A to busbar B

$$S_{AB} = V_A^*(V_A - V_B)A + V_A^* . (V_A - V_B) . jB + V_A^2 . jY/2 \quad (7.7)$$

Power flowing from busbar B to busbar A

$$S_{BA} = V_B^*(V_B - V_A)A + V_B^* . (V_B - V_A) . jB + V_B^2 . jY/2 \quad (7.8)$$

The equations (7.5), (7.6), (7.7) and (7.8) can be used by two general equations.

$$S_{JK} = -V_J^*(V_J - V_K)A(J,K) - V_J^* . (mV_J - V_K)jB(J,K) - V_J^2 . jY/2 \qquad (7.9)$$

$$S_{KJ} = -V_K^*(V_K - V_J)A(J,K) - V_K^*(1/mV_K - V_J)jB(J,K) - V_K^2 . jY/2$$

where A(J,K)+jB(J,K) is a mutual addittance of an off-nominal admittance matrix.

In case of a transformer with J being an A busbar

A, Y are zero, and n is represented by n.

Hence

$$S_{JK} = V_J^*(nV_J - V_K)jB(J,K)$$

$$S_{KJ} = V_K^*(1/nV_K - V_J)jB(J,K)$$

If K is an A busbar, m will be represented by 1/n.

In case of a transmission line, m is represent by 1.

The actual formulae derived for use in the computation are as follow:

$$\left.\begin{aligned}
P(K,m) &= -A(K,m)\{VP(K)(VP(K)-VP(m)+VQ(K)(VQ(K)-VQ(m))\} \\
&\quad +B(K,m)\{VP(K)(TO.VQ(K)-VQ(m)-VQ(m)(TO.VP(K)-VQ(m))\} \\
Q(K,m) &= -A(K,m)\{VP(K)(VQ(K)-VQ(m)-VQ(K)(VP(K)-VP(m))\} \\
&\quad -B(K,m)\{VP(K)(TO.VP(K)-VP(m)+VQ(K)(TO.VQ(K)-VQ(m))\} \\
&\quad +(VP(K)^2+VQ(K)^2)YZ \\
P(m,K) &= -A(K,m)\{VP(m)(VP(m)-VP(K))+VQ(m)(VQ(m)-VQ(K))\} \\
&\quad +B(K,m)\{VP(m)(1/TOVQ(m)-VQ(K))-VQ(m)(1/TO.VP(m)-VP(K))\} \\
Q(m,K) &= -A(K,m)\{VP(m)(VQ(m)-VQ(K)-VQ(m)(VP(m)-VP(K))\} \\
&\quad -B(K,m)\{VP(m)(1/TO.VP(m)-VP(K))+VQ(m)(1/TO.VQ(m)-VQ(K)\} \\
&\quad +(VP(K)^2+VQ(K)^2)YZ
\end{aligned}\right\} \quad (7.10)$$

where $P(K,m)+jQ(K,m)$ is a power going from busbar K to m.

$P(m,K)+jQ(m,K)$ is a power going from busbar m to K.

$A(K,m)+jB(K,m)$ is a mutual components between busbar K and m in the system admittance matrix.

$VP(m)+jVQ(m)$ is a busbar m voltage.

$VP(K)+jVQ(K)$ is a busbar K voltage.

TO depending on the type of busbar.

YZ a shunt component of a line constant.

Admittance matrix correction for off-nominal value transformer has been previously described.

The corrected nodal admittance at busbar A

$$B(A,A) = B(A,A)+B(A,B)-n^2B(A,B) \qquad (7.11)$$

The corrected mutual admittance between busbar A and B

$$B(A,B) = n.B(A,B) \qquad (7.12)$$

The first part of the output programme is an admittance matrix correction.

The second part is an injection power calculation, the sign is a generator and the negative sign is a load.

The third part is a line power flow calculation.

A complete system admittance and voltages including the slack busbar voltage are read.

The new value of transformer obtained from the voltage solution and its terminal busbar number are read one after another. When a transformer is read, it will be checked if it is at nominal value. If it is the next transformer will be read. If it is not, the A-nodal admittance and mutual admittance between A and B busbar will be corrected by the equation 7.11 and 7.12. The off-nominal ratio admittance matrix will be obtained finally.

The next stage, busbar are considered one after another. At each busbar consideration, an injection current will be worked out by the equation (7.1), and the magnitude and degree of the busbar voltage will be found. The power injection is the result of the injection current and busbar voltage calculated by the equation (7.2). The values of magnitude of voltage, its degrees and busbar injection power will be typed out at the end of this stage.

Power loss is the summation of all busbar injection powers, the difference between the total power generated and total load.

The data of line flow is quite complicated, an information of a line are put in one card. The first two datas are the terminal busbars. The third one is a transformer value, if it is not, 1 is put. The forth data indicates what kind of the first data is, 1 means busbar A, 0 means busbar B, and -1 means an ordinary transmission line. The fifth data is a shunt of a network transmission line, it will be zero for transformer.

The line power is calculated by the equation 7-10, and the results are typed at the end of this stage.

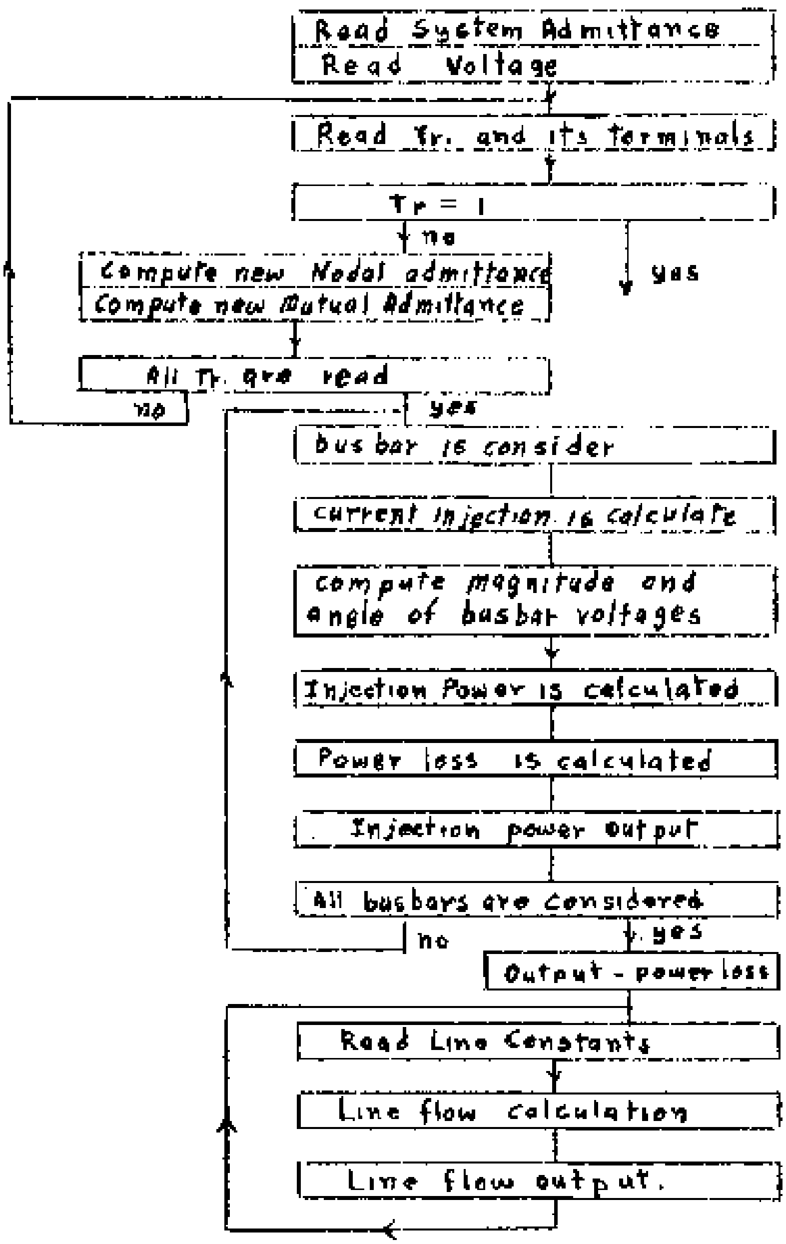

Figure 22 Flow Diagram for Output Programme