CHAPTER 2

THEORETICAL CONSIDERATION

2.1. Mathematic Pattern of Computation.

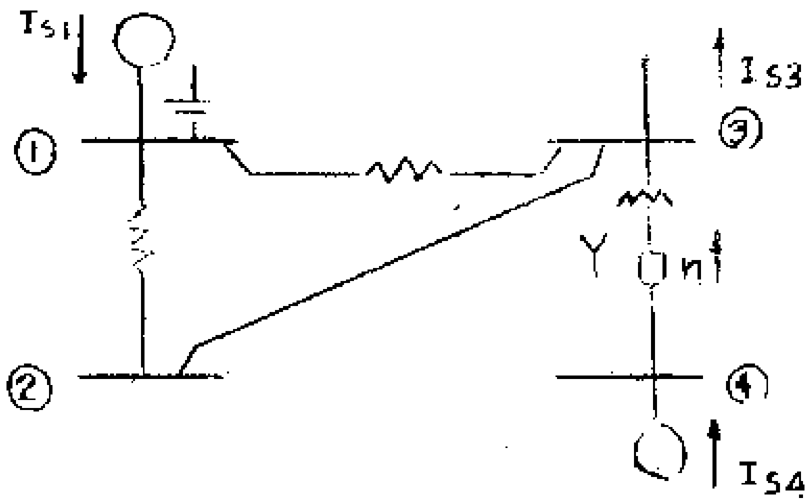

Fig. 1

The system in figure 1 may be expressed at nominal ratio transformer in nodal current equations.

$$I_{s1} = A_{11}V_1 + A_{12}V_2 + A_{13}V_3 + A_{14}V_4 \qquad (2.1)$$

$$0 = A_{21}V_1 + A_{22}V_2 + A_{23}V_3 + A_{24}V_4 \qquad (2.2)$$

$$-I_{s3} = A_{31}V_1 + A_{32}V_2 + A_{33}V_3 + A_{34}V_4 \qquad (2.3)$$

$$I_{s4} = A_{41}V_1 + A_{42}V_2 + A_{43}V_3 + A_{44}V_4 \qquad (2.4)$$

Usually V_1 is considered a slack generator, and is defined constant. The system can be solved without equation 1. Hence:

$$-A_{21}V_1 = A_{22}V_2 + A_{23}V_3 + A_{24}V_4 \quad (2.2)$$

$$-I_{s3} - A_{31}V_1 = A_{32}V_2 + A_{33}V_3 + A_{34}V_4 \quad (2.3)$$

$$I_{s4} - A_{41}V_1 = A_{42}V_2 + A_{43}V_3 + A_{44}V_4 \quad (2.4)$$

$A_{21}V_1, A_{31}V_1$ and $A_{41}V_1$ are constant, and may be express- in terms of I_{m2}, I_{m3}, I_{m4} respectively.

In case of off-nominal ratio transformer, the nodal and mutual admittances of the busbars connected to the transformer will be changed to certain values. The details of changing will be described in a later section (sect. 6.6) The final system equations may be written.

$$I_{m2} = A_{22}V_2' + A_{23}V_3' + A_{24}V_4' \quad (2.2)$$

$$-I_{s3}' + I_{m3} = A_{32}V_2' + (A_{33} + A_{33}')V_3' + (A_{34} + A_{34}')V_4' \quad (2.3)$$

$$I_{s4}' + I_{m4} = A_{42}V_2' + (A_{43} + A_{43}')V_3' + (A_{44} + A_{44}')V_4' \quad (2.4)$$

where V_2', V_3', V_4' are the voltage solution.

The system equation may be in a form

$$I_{m2} = A_{22}V_2' + A_{23}V_3' + A_{24}V_4' \quad (2.2)$$

$$-I_{s3}' + I_{m3} + I_B = A_{32}V_2' + A_{33}V_3' + A_{34}V_4' \quad (2.3)$$

$$I_{s4}' + I_{m4} + I_A = A_{42}V_2' + A_{43}V_3' + A_{44}V_4' \quad (2.4)$$

where $-I_B = A_{33}V_3' + A_{34}V_4'$

$$-I_A = A_{43}V_3' + A_{44}V_4'$$

Hence:

$$\begin{pmatrix} I_{m2} \\ -I_{s3}' + I_{m3} + I_B \\ I_{s4}' + I_{m4} + I_A \end{pmatrix} = \begin{pmatrix} A_{22} & A_{23} & A_{24} \\ A_{32} & A_{33} & A_{34} \\ A_{42} & A_{43} & A_{44} \end{pmatrix} \begin{pmatrix} V_2' \\ V_3' \\ V_4' \end{pmatrix}$$

It is evident that the power at any node is found from

$$S_n = V_n \times I_{sn}$$

2.2. Matrix Arrangement.

In a big system, a large amount of core storage must be used for matrix storing. This storing area can be reduced to nearly its half size, since the matrix is a symmethrical one. A half of mutual components along the diagonal matrix included the diagonal is sufficient for the computation. The element is referred to as a one subscripted matrix as follow:-

Matrix arrangement.

J-K

1-1	1-2	1-3	1-4	1-5	1-6
	2-2	2-3	2-4	2-5	2-6
		3-3	3-4	3-5	3-6
			4-4	4-5	4-6
				5-5	5-6
					6-6

$$M = \begin{pmatrix} 1 & 2 & 4 & 7 & 11 & 16 \\ & 3 & 5 & 8 & 12 & 17 \\ & & 6 & 9 & 13 & 18 \\ & & & 10 & 14 & 19 \\ & & & & 15 & 20 \\ & & & & & 21 \end{pmatrix}$$

The first matrix is a two subscripted matrix, with the first subscript is row number and the second one is column number. The later matrix is one subscripted matrix, which is used in place of the above. The element is called by a two subscripted matrix method, and these numbers will be turned to one subscripted matrix by the formula

$$M = J(J-1)/2 + K$$

where J is a higher number.

<u>**EX.**</u> The matrix multiplication is as follow:-

$$\begin{matrix} (4) & (5) & (6) & (9) & (13) & (18) \end{matrix}$$

$$\begin{vmatrix} 1\text{-}3 & 2\text{-}3 & 3\text{-}3 & 3\text{-}4 & 3\text{-}5 & 3\text{-}6 \\ \\ \end{vmatrix} \quad \begin{vmatrix} I_1 \\ I_2 \\ I_3 \\ \vdots \end{vmatrix}$$

needed	called	formula	Result
k-m	k-m		4
1-3	3-1	k(k-1)/2 + m	5
2-3	3-2	k(k-1)/2 + m	6
3-3	3-3	k(k-1)/2 + m	9
3-4	3-4	m(m-1)/2 + k	13
3-5	3-5	m(m-1)/2 + k	18
3-6	3-6	m(m-1)/2 + k	

With the help of a suitable formula, the one subscripted system can be used correctly by a two subscripted matrix refference.

2.3 System of A-C Power Computation.

There are two concepts of an alternating power computation.

1. $P + jQ = V^{*}I$

Where V^{*} is a conjucate voltage of V

Hence

$$P + jQ = (VP - jVQ)(IP + jIQ)$$

$$= (VP \times IP + VQ \times IQ) + j(VP \times IQ - VQ \times IP)$$

$$P = VP \times IP + VQ \times IQ$$

$$Q = +VP \times IQ - VQ \times IP$$

This system will give a negative reactive power for inductive load.

2. $$P + jQ = V.I^*$$

where I^* is a conjucate current of I.

Hence

$$P + jQ = (VP+jVQ)(IP-jIQ)$$

$$= (VPxIP+VQxIQ)+j(-VPxIQ+VQxIP)$$

$$P = VPxIP+VQxIQ$$

$$Q = -VPxIQ+VQxIP$$

This system will give a possitive reactive power for inductive load.

These two concepts have no adventage over each other, it would not be difficult if for either of them to be used throughout. In this report, $P+jQ = V^* x I$ is used.

2.4 Representation of Component.

(a) Generator and Load.

A generator can be regarded as a current source at a busbar, while a load as a sink. Generators may be represented by a current flowing into busbar, as well as loads represented by a currents flowing out of busbars. It is convenient in handling the problem by this method, since a line constant matrix is not changed at all. In the voltage solution, the load, generator or synchronous condensor will be found from the current injected at its busbar.

(b) Synchronous Condenser.

Synchronous condenser is regarded as a current source. Its value can be varied within the limits depending upon the voltage at that busbar.

(c) Transformer.

Transformer at nominal ratio is normally represented by a single admittance between its two terminals as in fig. 2

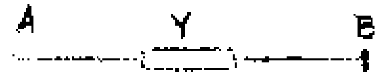

Figure 2

Representation of nominal Tr

At off-nominal ratio, it can be considered as an ideal auto-transformer as in fig. 3

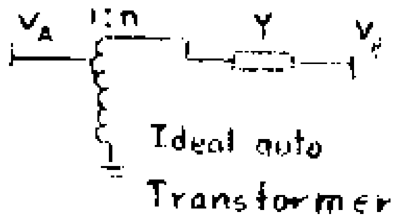

Figure 3

Representation of off-nominal Transformer

The transformer is connected between node A and node B. Z or Y is referred to B side and the ratio of transformer is n where n is also referred to the B side.

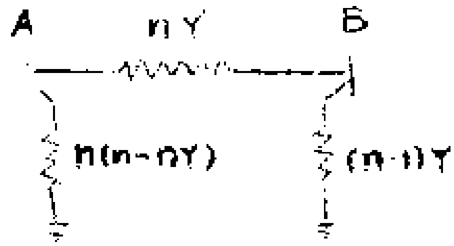

Figure 4 Equivalent circuit of off-nominal ratio transformer

The equivalent admittance can be represented the off-nominal ratio transformer as in fig. 4). This equivalent admittance will be used in the computation in this report.

(d) Line Constant.

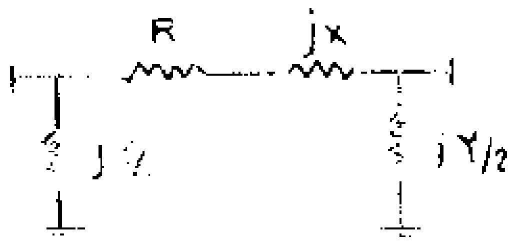

Figure 5 Admittance representation of transmission line

Regarding the length of the transmission line, the line constant between two nodes can be simply represented by a network. The mutual component is an impedance connected to the shunt susceptances at both sides.

In a voltage solution, shunt susceptances are added to its terminal capacitance forming a nodal admittance.

In the output programme, the current passing through their susceptances must be taken into consideration to obtain the actual power flow from a particular busbar.

(c) Capacitor.

Usually fixed capacitor is connected to a busbar to compensate for the effect of inductive reactive load, when that busbar is not very large. The terminal voltages will be raised. This shunt capacitor can be represented by a susceptance, and added to formed a nodal admittance.

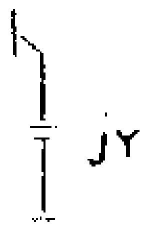

Figure 6
Shut condenser.