Chapter 6

Dynamic Programming for Automatic Sectionalization

6.1. Introduction

A problem facing all users who apply Diakoptics is that, they do not know to tear the system into subsystems in an appropriate way. The automatic tearing method presented in reference 64 is used to find the optimum tearing. This method is based on the principle of Dynamic Programming. However in this dissertation there is an improvement to the automatic tearing method and the Dynamic Programming (37,38,65) applied as well.

6.2. The Automatic Tearing Method

By the Dynamic Programming, the minimization of a performance index is:

$$\mathrm{Jmin}(\dot{X}_1,\dot{X}_2,\ldots,\dot{X}_k,\ldots,\dot{X}_n) \leqslant J(\dot{X}_1,\dot{X}_2,\ldots,X_k,\ldots,\dot{X}_n) \qquad (6.1).$$

where $\dot{X}$ is X at optimum point.

For a Power System, the performance index or cost function to minimize the memory storage is defined as:

$$J = \sum_{i=1}^{n} M_i^2 + K^2 \qquad (6.2).$$

where: M_i is the total number of buses in area i.

K is the total number of tie-lines in the system.

n is total number of areas in the system.

By Dynamic Programming, the optimum solution can be found through the following steps:

1. Assume that only bus i can change area, but other buses are fixed.

2. Move bus i to every area, and calculate corresponding J.

3. Find minimal vale of J, then set bus i to that area.

4. Repeat step 2 for every bus and check the final cost (the value of J.) If the cost does not change the final solution is obtained, if not go back to step 2 again.

Note that, eq (6.2) is a sum of square, so that the optimum point is not unique.

In DLF or FDLF, the optimal processes can be modified by including network conditions. For B'-network, since the swing bus has never been included in [B'], the bus should be put into an appropriate area, to minimize the matrices's size. Also in B"-network, this rule can be applied, the swing and PV-bus should be put into the appropriate areas. However B'and B"-network may be differently torn.

Example Consider an IBM 14-node network (66) in Fig. 6.1, bus 7 is system swing bus, and buses 1, 4 and 5 are PV-bus. It is torn to 3 areas:

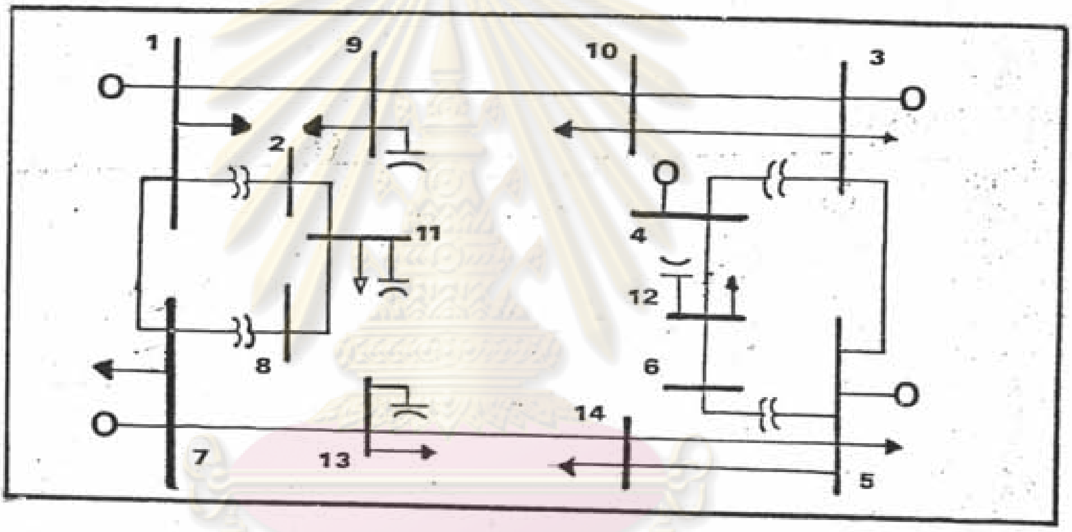

Fig. 6.1 IBM 14-Node Network.

<u>Case 1</u> Swing bus and PV-bus are excluded an optimum solution is shown in Fig. 6.2.

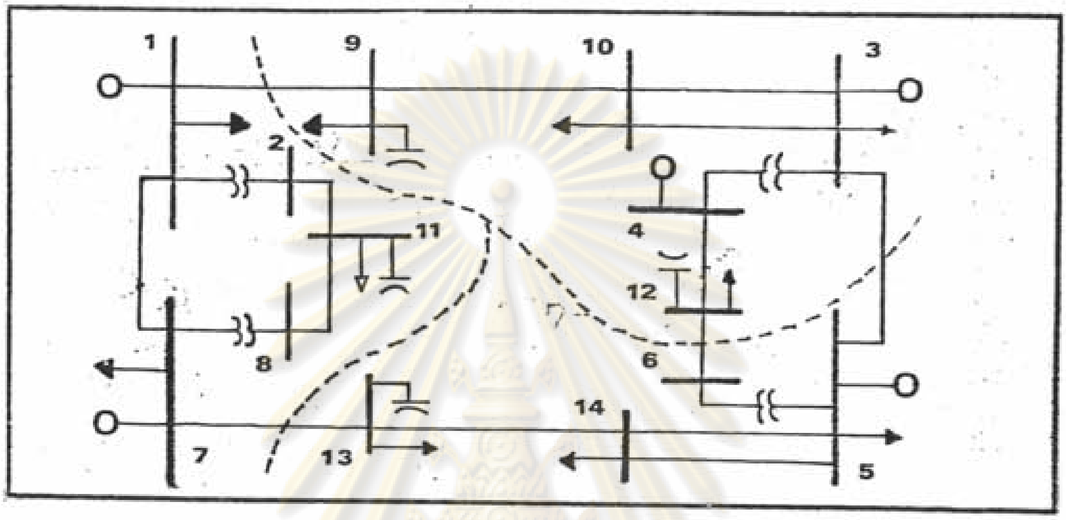

Fig. 6.2 Optimum Tearing of Original Network.

Area 1 has buses : 1 2 7 8 11 : total 5 buses.
Area 2 has buses : 3 4 9 10 12 : total 5 buses.
Area 3 has buses : 5 6 13 14 : total 4 buses.

Total tie-line is 4 lines.

Cost is 82.

Note that the second possible solution is :

Area 1 has buses : 1 2 7 8 11 : total 5 buses.
Area 2 has buses : 3 4 9 10 : total 4 buses.
Area 3 has buses : 5 6 12 13 14 : total 5 buses.

Total tie-line is 4 lines.

Cost is 82.

It shows that the solution is not unique.

Case 2 Swing bus and PV-bus are included, the solution of B' and B"-network are shown in Fig. 6.3 and 6.4 respectively.

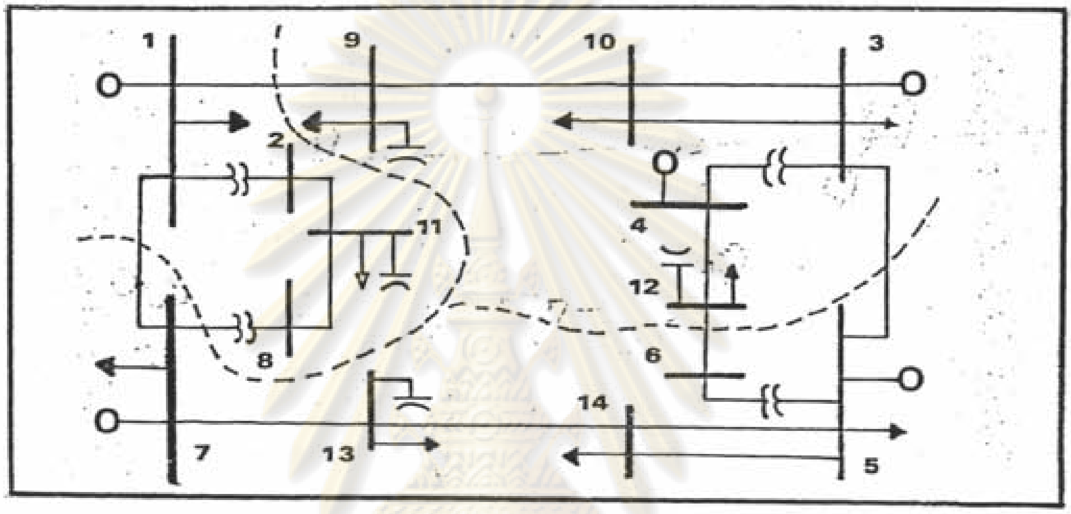

Fig. 6.3 Optimum Tearing of B'-Network.

Area 1 has buses : 3 4 7 9 10 12 : total 6 buses.

Area 2 has buses : 1 2 8 11 : total 4 buses.

Area 3 has buses : 5 6 13 14 : total 4 buses.

Total tie-line is 3 lines.

Cost is 66.

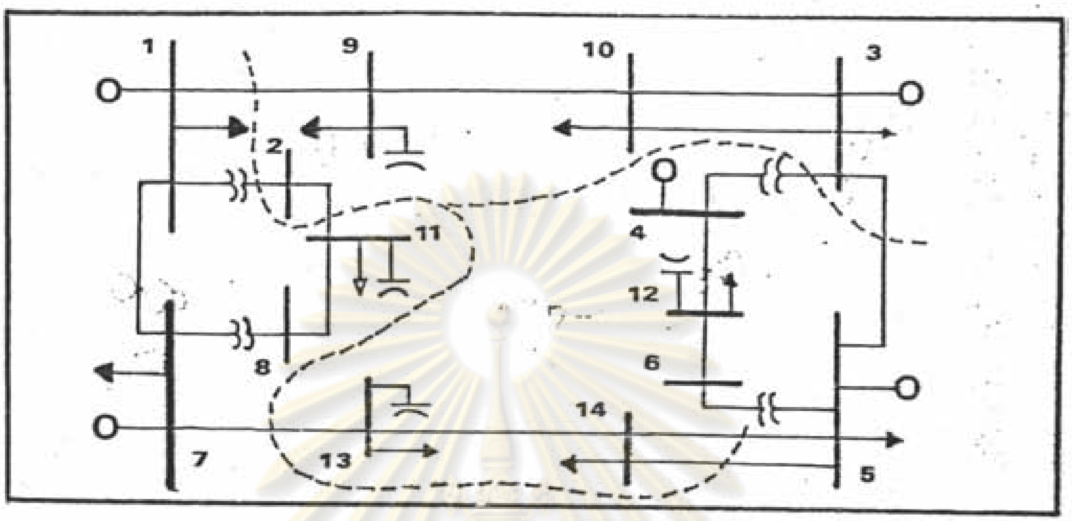

Fig. 6.4 Optimum Tearing of B"-Network.

Area 1 has buses : 1 4 5 6 7 8 11 : total 8 buses.
: 12 :

Area 2 has buses : 3 9 10 : total 3 buses.

Area 3 has buses : 2 13 14 : total 3 buses.

Total tie-line is 1 lines.

Cost is 35.

Note that, the time of multiplication is minimized by the index:

$$J = 2 \sum_{i=1}^{n} M_i^2 + K^2 \qquad (6.3).$$