5.10 Conclusions

This chapter has presented a variety of methods for evaluating the reliability of complex systems. It also illustrates the relationships and similarities between the various techniques since many of the methods are similar in concept although their formal presentation may seem different. The reader will find in the literature concerned with reliability evaluation, that all these methods are used in one form or another for different purposes. It is not possible to specify which method is most appropriate for a given system problem since most methods can be used for any problem. Furthermore, it is sometimes found that the most suitable solution to a given problem is to employ a mixture of techniques. This is frequently done in safety system analysis [20] in which event trees, fault trees, state enumeration or truth tables are all used in combination. Example 5.15 presented an approach in which conditional probability and state enumeration methods are used within the same problem. The analyst should appreciate that there are a number of alternative techniques available and the first task is to assess the particular problem and to judge which method may be most relevant in order to achieve the required reliability assessment. It is hoped that the numerical examples that have been included in this chapter to illustrate the various techniques will assist the reader and user of these techniques in this assessment and judgement.

Problems

1 In the system shown in Figure 5.22a, system success requires that one of the following paths must be available: AD, BD, CE, BE. Write an expression for the reliability of this system. If all the components have a reliability of 0.9, what is the system reliability?

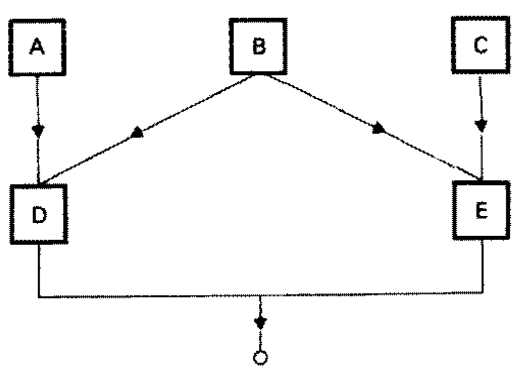

Fig. 5.22a

Compare this with the reliability of the system shown in Figure 5.22b.

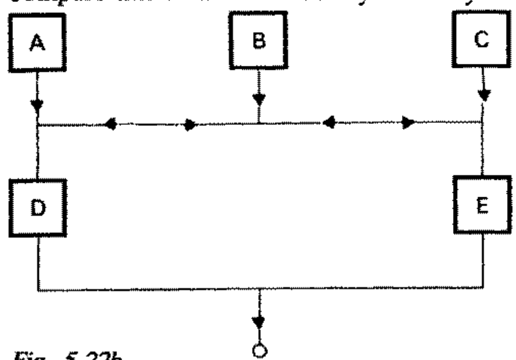

Fig. 5.22b

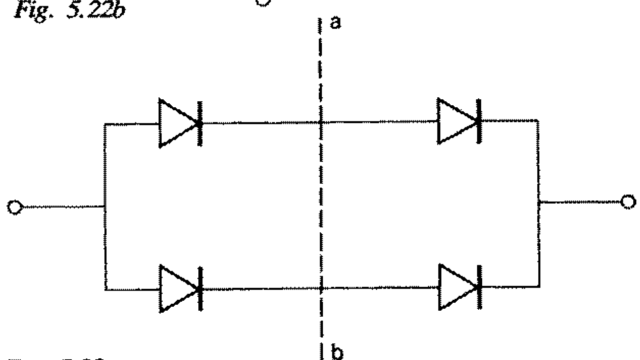

Fig. 5.23

2 For the quad system shown in Figure 5.23, calculate the improvement factor over a single diode. The following data of the system is given:
All diodes are identical.
Probability of normal operation of a diode, $P_n = 0.97$.
Probability of open circuit of a diode, $P_o = 0.01$.
Probability of short circuit of a diode, $P_s = 0.02$.
The improvement factor can be defined as

$$\text{I.F.} = \frac{\text{Probability of failure of one diode}}{\text{Probability of failure of a quad}}$$

Under what conditions would you consider joining the link ab?

3 Develop an expression for the reliability of the system shown in Figure 5.24.

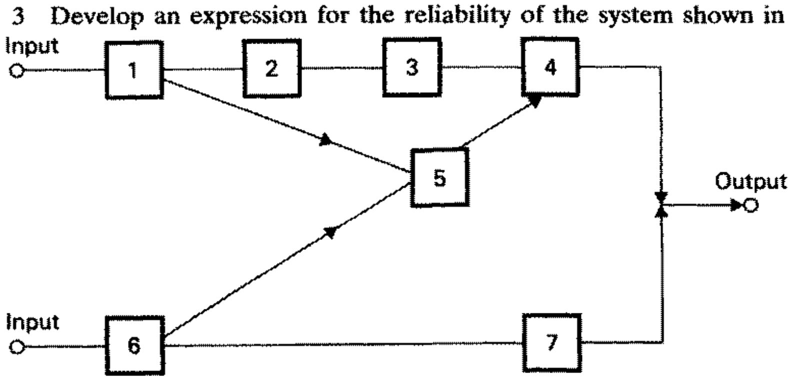

Fig. 5.24

Calculate the system reliability if all the individual components have a reliability of 0.9.

4 A system consists of 3 components in parallel with reliabilities designated as R_1, R_2 and R_3. The system requires at least 1 component to work for system success. Find an expression for system reliability using (a) conditional probability, (b) minimal cuts sets, (c) minimal tie sets, and (d) event tree methods.

5 Find the minimal cuts and tie sets of the system shown in Figure 5.25 and construct the reduced event tree of the system. Calculate the unreliability of the system if all components are identical with a reliability of 0.95 using the conditional probability approach and the event tree method. Compare these values with the upper bound value given by the minimal cut set method.

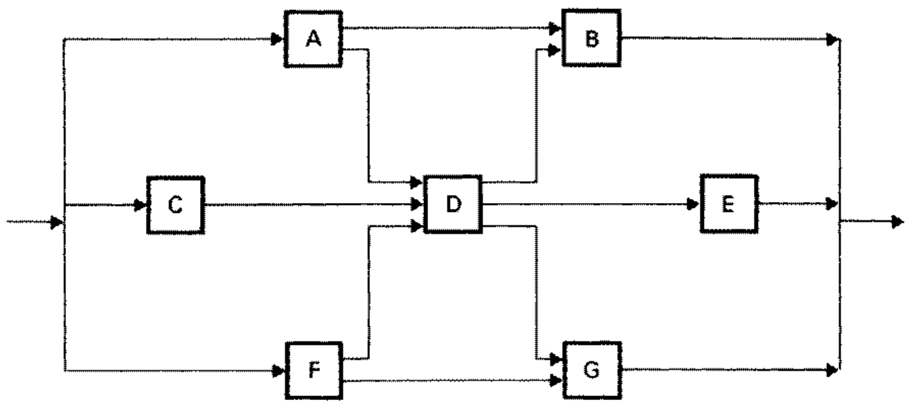

Fig. 5.25

6 Develop an expression for the reliability of the system shown in Figure 5.26. Calculate the system reliability if all components have a reliability of 0.9. Estimate the system reliability using the minimal cut set technique.

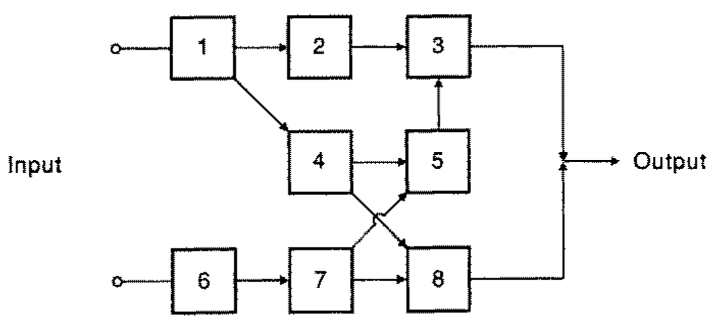

Fig. 5.26

7 The system shown in Figure 5.27 has one input I and two outputs L_1 and L_2. At least one path between the input and an output is required for the output to be successful. Each component is identical and has a reliability of 0.99. Evaluate the reliability of each output.

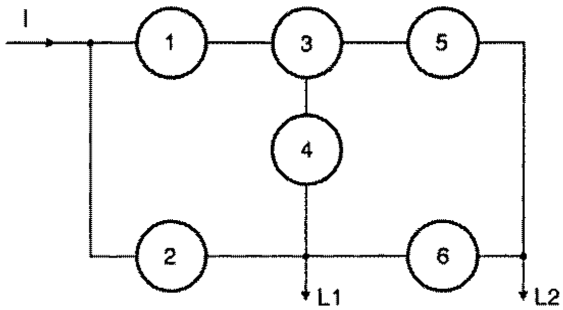

Fig. 5.27

8 Briefly discuss the merits of the conditional probability technique for evaluating system reliability. Using this technique, evaluate the reliability of the system shown in Figure 5.28 for an operating period of 1000 h and its MTTF if:

(a) the times to failure of the components are exponentially distributed;
(b) each component has a MTTF of 10,000 h;
(c) the system requires at least one path to exist between the input A and output B for successful operation.

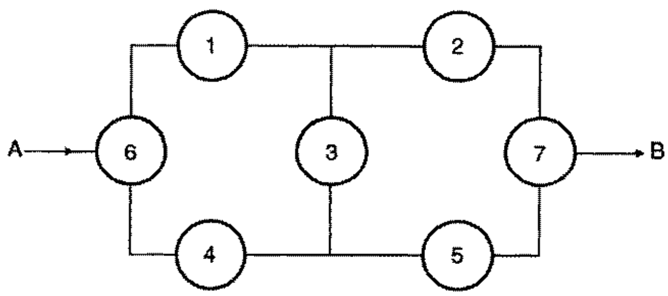

Fig. 5.28