Electric Power Generation Modelling By Using Decimal to Binay Conversion and Genetic Algorithm Technique

*Chanabasappa Bheraji, **Soumya Honyal
P.G. Scholar Electrical and Electronics Engineering
SDM College of Engineering and Technology
Dharwad, India
Email-Id: bheraji43@gmail.com

***Dr. S.B Karajgi
Dept.Electrical and Electronics Engineering
SDM College of Engineering and Technology
Dharwad, India

ABSTRACT

Generation system reliability assessment is a vital factor for planning the power system that can be performed by using probabilistic or deterministic methods. The probabilistic techniques have more advantages over deterministic methods. However, Probabilistic method involves complicated modelling. Generation modelling is a basic requirement for the assessment of reliability of the system. One known form of the generation model is the Capacity Outage Probability Table (COPT). This paper analyses the different techniques involved in developing COPT such as Decimal to Binary Conversion(DBC) and Genetic Algorithm(GA). The COPT is obtained from two techniques are found to be comparable. The techniques used are proven to be an effective approach to build the generation model.

Keywords—Decimal to Binary; Genetic-Algorithm; Capacity Outage Probability Table.

I. INTRODUCTION

Generation adequacy evaluation is an important aspect in planning power system. In order to keep preferred stage of reliability, the machine ought to have a potential reserve in extra of the total load. Many strategies were evolved to determine the desired degree of capacity reserve in a device. These strategies may be divided into two types, one is probabilistic and other is deterministic method [1] - [2]. In order to perform probabilistic adequacy assessment of the system two models are used one is generation model, and the load model. The commonly used load models are the Daily Peak Load Variation Curve (DPLVC) and the Load Duration Curve (LDC). In order to perform generation model, it is necessary to establish the Capacity Outage Probability Table (COPT). It gives information about the available or unavailable capacity reserves and their corresponding probabilities. The COPT has been developed by employing different techniques [3] - [4]. These approaches can be classified into two methods one is analytical method and simulation techniques. Analytical Procedures require mathematical modelling for the energy producing units. The Units fashion are then mixed to generate the system states which will create the burden on the developing the COPT. Monte-Carlo Simulation (MCS) does not require complicated mathematical modelling, however a huge variety of simulation is considered to reach an acceptable level. MCS is random Process Wherein System states are repeated unnecessarily. In Genetic-Algorithm (GA) method does not require analytical representation to recover the system states which in flip formalize the COPT.

GA is random but controlled technique. The appearance of formerly generated system states can be managed and reduced. GA has emerged as an effective seek tool used for seek and optimization [5] - [6]. In Decimal to Binary Conversion (DBC) approach it is not requiring complex representation, nor consumes more time during simulation. DBC approach is extensively and commonly carried out in digital gadget and computing.

II. DECIMAL TO BINARY CONVERSION

DBC technique is employed to crate COPT. It creates single column array that carries decimal numbers. Obtained numbers are converted into decimal numbers. These numbers are transformed to their binary illustration and stored in binary states array. This array is used to calculate the states possibilities and capacities. Following steps are employed in order to create COPT.

1. Define the No. of generating unit that is 2^G. Where G = No. of generating Units.

2. Establish an array states which contains decimal numbers from 0,1,2,3,4…….. ($2^G - 1$). The size of decimal states array is given as 2^G*1.
3. From the decimal states array converted it into corresponding binary numbers. This operation consequence in a new binary array specific as the binary states array. Every row equals to the No. of generating units used in the system. The states of the system are represented as 0 & 1. The 1 represents the system capacity available. The 0 represents the system capacity unavailable. The general representation of binary states array is given by,

$$Binary\ states\ array = \begin{bmatrix} State_{11} & State_{12} & . & . & State_{1G} \\ State_{21} & State_{22} & . & . & State_{2G} \\ . & . & . & . & . \\ . & . & . & . & . \\ State_{2^G{}_1} & State_{2^G{}_2} & . & . & State_{2^G{}_G} \end{bmatrix}$$

4. State Capacity Available is calculated by using Eq.1

$$\text{State Capacity Available}_p\ (\text{MW}) = \sum_{q=1}^{G} State_{pq} * Cap_q \text{-----------------} (1)$$

Where,
$State_{pq}$: The State of the q^{th} unit in the p^{th} system state
Cap_q: The capacity of the q^{th} unit.

In creating COPT, the Capacity Unavailable is calculated using Eq.2

$$\text{State Capacity Unavailable}_p\ (\text{MW}) = \text{TIC} - \text{State Capacity Available}_p \text{ --------}(2)$$

Where,
TIC = The Total Installed Capacity (MW)

5. The Individual State Probability is calculated using Eq.3

$$\text{Individual State Probability}_p = \prod_{q=1}^{G} Prob_q \text{-------------} (3)$$

Where,
G = No. of Generating units.
$Prob_q = FOR_q$, if $State_{pq} = 0$
$= 1 - FOR_q$, if $State_{pq} = 1$

6. In calculating there may be some states which have equal capacity, in this case these are replaced by the single state with the same capacity level. The probability of the states obtained by adding the all the states.

7. Cumulative Probability is calculated by using Eq.4

$$\text{Cum Prob}_p = \text{Cum Prob}_{p-1} + \sum_{p=1}^{K} \text{State Prob}_p \text{ ------------------ } (4)$$

Where,
K = Total Number of states in p^{th} generation.
$\text{Cum Prob}_{0-1} = 0$

CASE STUDY: 1

The above mentioned technique is explained by considering a small system with three generating units as shown in table 1. G_1, G_2 and G_3 represents the number of generating units.

Table 1: DATA FOR TEST SYSTEM

UNIT	Capacity (MW)	FOR
G1	10	0.02
G2	30	0.04
G3	20	0.10

The decimal states array = (0 1 2 3 4 5 6 7)’

The decimal states array is converted into its binary array as shown below.

$$\text{Binary States array} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

In the binary states array every row indicates the state of the system with three units. From the Eq.1 the State Capacity Available is calculated as shown below.

State Capacity Available 1 = 0*10 + 0*30 + 0*20 = 00 MW
State Capacity Available 2 = 0*10 + 0*30 + 1*20 = 20 MW
State Capacity Available 3 = 0*10 + 1*30 + 0*20 = 30 MW
State Capacity Available 4 = 0*10 + 1*30 + 1*20 = 50 MW
State Capacity Available 5 = 0*10 + 0*30 + 0*20 = 10 MW
State Capacity Available 6 = 30 MW
State Capacity Available 7 = 40 MW
State CapacityAvailable 8= 60 MW

From the above we observe that state 3 & 6 are of same capacity levels. Hence, they are combined into single state.

The state capacity unavailable is calculated using Eq.2 TIC = 60 MW.

State Capacity unavailable 1 = 60 – 0 = 60 MW
State Capacity unavailable 2= 60 – 20 = 40 MW
State Capacity unavailable 3= 60 – 30 = 30 MW
State Capacity unavailable 4= 10 MW
State Capacity unavailable 5= 50 MW
State Capacity unavailable 6= 30 MW
State Capacity unavailable 7= 20 MW
State Capacity unavailable 8= 0 MW

The individual State Probability is Calculated using Eq.3

Individual State Probability 1 = 0.02*0.04*0.10 = 0.00008
Individual State Probability 2 = 0.02*0.04*(1-0.10) = 0.00072
Individual State Probability 3 = 0.02*(1-0.04) *0.10 =0.00192
Individual State Probability 4 = 0.01728
Individual State Probability 5 = 0.00392
Individual State Probability 6 = 0.03528
Individual State Probability 7 = 0.09408
Individual State Probability 8 = 0.84672

The Cumulative Probability is Calculated by Using Eq.4

Cumulative Probability 1 = 1.00000
Cumulative Probability 2 = 0.99992
Cumulative Probability 3 = 0.99600
Cumulative Probability 4 = 0.99528
Cumulative Probability 5 = 0.95808
Cumulative Probability 6 = 0.86400
Cumulative Probability 7 = 0.84672

The COPT obtained using DBC method is as shown Table 2. As mentioned in the above the state 3 & 6 has same capacity so, their probabilities are added to obtain the single probability. Finally, they are arranged in descending order of their capacity available.

From the Table 2 we observe that the state probability is equal to 1. This represents that all the states of the system are included. If state probability is not equal to 1 then reconsider the system states which are not recovered in the previous states.

Table 2 : THE DBC USING FINAL COPT

State	Capacity Available (MW)	Capacity Unavailable (MW)	Individual State Probability	Cumulative Probability
1	60	0	0.00008	1.00000
2	50	10	0.00392	0.99992
3	40	20	0.00072	0.99600
4	30	30	0.03720	0.995280
5	20	40	0.09408	0.958080
6	10	50	0.01728	0.864000
7	0	60	0.84672	0.846720
Total State Probability			1.00000	

III. GENETIC ALGORITHM

Another method of creating COPT is by the Genetic Algorithm. The GA generates the machine states represented as the chromosomes and match individuals are sampled to construct the COPT. System with generating unit's G which may be capacity available or capacity unavailable. The total states of the system are given by, 2^G. The total obtained probabilities of all the states should become equal to 1. For the larger systems it not possible to include the all states of the system while constructing COPT. Some of these states have low possibility of prevalence because of this they are rare to rise. Due to the low probability of occurrences they do not affect reliability assessment of the system. In reality, its miles the same old exercise to truncate those states out of the COPT [7]. The proposed method of GA technique is to construct COPT is designed to truncate the significant states. The steps are described as shown below:

1. First choose the initial population randomly. The selected population has individual chromosomes. So, each chromosome indicates the state of the system that is encoded as binary string the length is equal to No. of generating units considered. The probability of occurrences is calculated using Eq.5 in two states.

$$\text{Prob}_q = \begin{cases} 1 - \text{FOR}_q \text{ if State}_{pq} = 1 \\ \text{FOR}_q \text{ if State}_{pq} = 0 \end{cases} \quad \text{---------} (5)$$

Where,

State_{pq} = The state of q^{th} unit in system state p,
Prob_q = The State Probability of q^{th} unit,
FOR_q = The Forced Outage Rate of q^{th} unit.

2. The fitness of individual state is determined by calculating its probability. As in the previous method (DBC) the state probability is calculated from Eq.3. In the selected population there may be some states which are repeated. The fitness of these states is about to a completely small value so that they are disregarded. The machine state array will be used later to establish COPT.
3. The system capacity available and unavailable are calculated using Eq.1 & 2. As calculated in the DBC technique.
4. Tournament Selection technique is used to create system states. The states which have better chance have greater probabilities to occur. The selected population are randomly separated into subgroups and population members that are having more fitness are selected for further reproduction processes. The system states with lower probability are not included in this process.
5. In this step new generation is created. To maintain track of the development in gathering the fitness of machine states, the entire probability of the accrued states in the device states array is calculated. The probability is termed as cumulative probability it is calculated Eq.4.

CASE STUDY: 2

Same system data is considered from Table 1. the possible system states are 2^3 which is equal to 8. If size of the system is small, then all possible states are obtained by GA search method. In this case population size of 10 is taken as shown in Table 3.

Table 3 : TEST SYSTEM FOR THE INITIAL POPULATION

Unit	G1	G2	G3
System State	$State_{pq}$		
1	0	0	0
2	0	0	1
3	1	0	0
4	1	1	0
5	1	0	1
6	0	1	1
7	1	0	0
8	1	0	0
9	0	1	0
10	0	1	1

State probability is calculated using Eq.3 as shown in Table 4. In this table the states are repeated that is state 3, 6 & 7. Their values are appearing to be zero. Hence, they can be neglected.

Table 4 : INITIAL POPULATION FOR THE STATE PROBABILITY

System State	State Probability
1	0.00008
2	0.00072
3	0.00000
4	0.09408
5	0.03528
6	0.00000
7	0.00000
8	0.00392
9	0.00192
10	0.01728

From Eq.1 & 2 state capacity available and unavailable is calculated. As shown in Table 5.

Table 5: FIRST GENERATION FOR THE SYSTEM STATES ARRAY

State	Capacity Available (MW)	Capacity Unavailable (MW)	Individual State Probability
1	0	60	0.00008
2	20	40	0.00072
3	40	20	0.09408
4	30	30	0.03528
5	10	50	0.00392
6	30	30	0.00192
7	50	10	0.01728
Cumulative Probability $_p$			0.15328

From the Table 5 we observe that cumulative probability is not equal to 1. Hence, again consider the states which are not recovered. The new population is considered as shown in Table 6.

Table 6: SECOND GENERATION OF THE NEW POPULATION

System State	Unit 1	Unit 2	Unit 3
1	1	1	0
2	1	1	0
3	1	1	0
4	0	1	0
5	1	1	0
6	1	1	0
7	1	0	1

8	1	1	0
9	1	1	1
10	0	0	1

From the Table 7 We observe that Cumulative Probability becomes equal to 1. Which means that all the states are recovered in the considered system states. In the final step the states which have same capacities that is state's 4 & 6 are combined together. The final COPT is as shown in Table 8. The Cumulative probability is equal to 1.

Table 7: AFTER THE SECOND GENERATION SYSTEM STATES ARRAY

System State	Capacity Available (MW)	Capacity Unavailable (MW)	State $Prob_p$
1	0	60	0.00008
2	20	40	0.00072
3	40	20	0.09408
4	30	30	0.03528
5	10	50	0.00392
6	30	30	0.00192
7	50	10	0.01728
8	60	0	0.84672
Cumulative Probability			1.00000

Table 8: THE FINAL COPT USING GA SEARCH TECHNIQUE

State	Capacity Available (MW)	Capacity Unavailable (MW)	l State Probability	Cumulative Probability
1	60	0	0.00008	1.00000
2	50	10	0.00392	0.99992
3	40	20	0.00072	0.99600
4	30	30	0.03720	0.995280
5	20	40	0.09408	0.958080
6	10	50	0.01728	0.864000
7	0	60	0.84672	0.846720
Total State Probability			1.00000	

IV. CONCLUSION

Generation adequacy assessment is a vital factor for planning the power system. To maintain preferred level of reliability the system should have capacity reserve in excess. Many techniques have been introduced in order to maintain required capacity reserve in the system. In this paper two methods are explained to calculate the Capacity Outage Probability Table (COPT).The results obtained were comparable. In DBC method binary representation 0 & 1is used to indicate the states of the system. It's not complicated and time consuming in order to generate system states. The second method of GA technique is very useful in large systems. The accuracy of this method to create generation model is dependent on the GA characteristics. Table 2 and 8 shows the final COPT.

REFERENCES

[1] IEE Committee Report,"Bibliography on the Application of probability Method inpower Method in power System ReliabilityEvaluation," 1971-1977 IEEE Transaction on power apparatus and system, vol.Pas-97.No.6,1978,pp.2235-2242.

[2] R.Billinton ," Bibliography on the Application of probability Method inpower Method in power System Reliability Evaluation ," IEEE Transaction on power Apparatus and system, vol.91,No.2,1972,pp.649-660.

[3] R.N Allan , R,Billinton. "Realiability Evaluation of npower system," plenum press,New York 1996.

[4] R.Billinton and A.Abdulwhab, "short-term generation unit maintenance scheduling in a deregulated power system using a probablistic Approach",IEEE,proc.-Gener.Trans,Vol.150,No,4,july 2003,PP.463-468.

[5] Abdulwhab, A. and Billinton, R.2004.Maintenance scheduling Using a Genetic Algorith (GA) with a probablistic Fitness Function,journalof Electric power components and system,Volume 32,Number 12,pp.1239-1254 (16).

[6] Billinton,R,Kumer,S.,Chowdhury,K.,Chu,K.,Debnath,K.,Goel,L.,Khan,E.,Kos,P.,Nourbakhsh,G., and oteng-Adjei, J.1989. A Reliability Test System for Educational purposes – Basic Data, IEEE Transaction on power system,Vol.4,No.3,pp.1238-1244.

[7] Allan,R.N., and Billinton R.,1966.Reliability Evaluation of power system,Plenum Press,New York.