THE MATHEMATICAL WAY FOR RELIABILITY OF IRAQI WEST NORTH REGION NETWORK USING P. T. M

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ABSTRACT

The **Reliability** is such an extensive subject that it would not be possible to deal with all its various methods in a single study. The present study thus has focused its attention on one of the **Reliability** methods that is the **Path Tracing Method**. The method is concerned a detailed explanation has been presented and being applied on the **400Kv of Iraqi West North super grid**. Method used matrix for calculating the **Reliability** its value depends on path of the power from generator (**Mussel mean dam and Paji p.s**) to the distribution in **Baghdad** .The number of rows equal to number of **paths** while the number of columns equal to the number of contains of **network** by using differential equation calculating the **Reliability of network**. As a conclusion its found that the quantity evaluation of **Reliability** give a clear vision for continuity of any system at work within safety limit and it can determine how a system might fail and the consequences of this failure.

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الخلاصة

الوثوقية موضو ع واسع بحيث لن يكون بالامكان تناول جميع طرقه المختلفة في بحث واحد لذا ركز البحث اهميته على واحدة من طرق الوثوقية وهي طريقة تتبع المسار حيث تم تقديم شرحا تفصيليا لهذه الطريقة وتطبيقها على منظومة الشبكة العظمى (400 kv) لمنطقة شمال غرب العراق وتتضمن هذه الطريقة انشاء مصفوفة تعتمد في قيمها على مسارات الطاقة من محطة التوليد والتي تشمل محطة سد الموصل ومحطة بيجي الى محطات التوزيع في بغداد حيث كان عدد الصفوف مساوي الى عدد تلك المسارات وعدد الاعمدة مساوي الى مكونات الشبكة ومن خلال المعادلات الرياضية تم حساب الوثوقية لهذه الشبكة. واستنتاجا نجد ان الحسابات الكمية للوثوقية تعطي مؤشرا واضحا لمدى استمرارية اي نظام في العمل ضمن حدود الامان ، كما تحدد كمية حدوث فشل المنظومة وما يترتب على هذا الفشل.

List of Nomenclature

$\overline{a}$ ………………………………… Unavailability of primary event

$\overline{A}$ …………………………………. Unavailability

M.C.S. ………………………………… Minimal Cut Set

M.C.S.s ……………………………… Minimal Cut Set System

M.M.D ……………………………… Mussel mean dam

MTFt ……………………………… Mean Time Failure

$\overline{r}$ ………………………………… Unreliability of system

$\overline{R}$ ………………………………… Unreliability

Λ_t ………………………………… Failure rate of top event

Λ ………………………………….. Failure rate

$\sum$ ………………………………….. Summation value

INTRODUCTION

An electrical power system consists of generation, transmission and distribution system .The ultimate aim of reliability analysis is the evaluation of the entire system performance so that overall reliability measurements can be obtained.

However this is a rather too ambitious and difficult task because of the very large number of components and complex interconnections. Therefore, it is more careful to calculate reliability measures separately for the generation, transmission and distribution system. An added advantage of this approach is that the weakest links and components can be spotted more easily and measures taken for reliability improvement.

Reliability improvement is possible through the use of better components and provision of redundancy. Redundancy in generation means additional generation capacity. Redundancy in transmission means that ties between stations and load centers should be stronger .This extra transmission capacity can be used to ignore overloading during usual operating conditions.

A reliability study can be undertaken only when a proper and reliable data bank of failure rates and repair times for various components is available. [3]

DEFINITION RELIABILITY

In general terms, reliability is measure of how a system performs it is expected function. Another system characteristic that closely associated with reliability is adequacy.

Reliability may be measured by the frequency, duration and magnitude of adverse effects on the electric supply. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system – adequacy and security. [2]

MEASURING RELIABILITY

There is no single index that is universally used to express the reliability of power system; reliability indices can be broadly categorized as either deterministic or probabilistic. Deterministic indices are calculated with known system parameters provide a static look at the system. Their advantage is that they can be easily measured; their deficiency is that they are poor representation of system reliability because they do not take unforeseen events into account very well. Operating reserve margin is an example of a deterministic index.

Probabilistic measures incorporate the dynamic nature of a power system. Statistical methods are used to account for future uncertainties in system components. These indices provides a much better indication of reliability but they are more difficult and take more time to calculate. Probabilistic reliability indices usually include the frequency, duration and magnitude of customer interruptions.Using these three parameters, various indices can be constructed.

To measure reliability to consider the two main types of system connectors that can be found in an electric network, series and parallel system. [2]

SERIES SYSTEMS

Consider a system consisting of two independence components A and B Connected in series, from reliability point of view, as shown in **Figure (1),** this arrangement implies that both components must work to ensure system success.

Let R_A, R_B= probability of successful operation of components A and B respectively. Since success and failure are mutually exclusive and complementary.

$R_A + Q_A = 1$ and $R_B + Q_B = 1$ …… (1.1)

The requirement for system success is that (both A and B must be working), the probability of system success or reliability will be:

$$R_S = R_A * R_B \quad \text{…………………………. (1.2)}$$

If there are now (n) components in series, equation (1.2) can be generalized to give

$$R_S = \prod_{i=1}^{n} R_i \quad \text{……….. (1.3)}$$

This equation frequently is referred to as (the product rule of reliability) since it establishes that the reliability of a series system is the product of the individual component reliabilities.

In some application it may be considered to be advantageous to evaluate the unreliability or probability of system failure rather than evaluating the reliability of system success. System success and system failure are complementary events and therefore for the two component system the unreliability (Q) is: [1]

$$Q_S = 1 - R_A R_B \quad \text{…….………… …. (1.4)}$$

$$Q_S = Q_A + Q_B - Q_A Q_B \quad \text{……………..... (1.5)}$$

Or for an (n) component system

$$Q_S = 1 - \prod_{i=1}^{n} R_i \quad \text{.............................. (1.6)}$$

PARALLEL SYSTEMS

Consider a system consisting of two independents A and B connected in parallel, from reliability point of view, as shown in **Figure (2).**

The system reliability R_p can be obtained as the complement of the system unreliability Q_p.

$$R_P = 1 - Q_A * Q_B \quad \text{………………….. (1.7)}$$

$R_P = R_A + R_B - R_A * R_B$ ……………..….. (1.8)

or for an (n) component system

$R_P = 1 - \prod_{i=1}^{n} Q_i$ …..………….. (1.9)

Also

$Q_P = Q_A * Q_B$ ………………… (1.10)

And for (n) component system

$Q_p = \prod_{i=1}^{n} Q_i$ …………………. (1.11)

It follows that the equations for a parallel system is of the same form as these of series system but with R and Q interchanged. In the case of parallel systems, equation (1.11) leads to the concepts of the product rule of unreliability's. However, unlike the case of the series systems in which, under certain circumstances, equation (1.5) can be reduced to simple summation), equation (1.8) cannot be simplified in this way since the Product ($R_A * R_B$) is, always reasonably comparable with the value of R_A and R_B. As conclusion in the case of series system the system reliability decreased as the number of series components was increased previous equation (1.3).

In the case of parallel system, however it is the unreliability that decrease as the number of parallel components is increased previous equation (1.11), and hence the reliability increases with the number of components. Increasing the number of parallel components increases the initial cost, weight and the volume of the system and increases the required maintenance; therefore it must be examined very carefully. The general principle is used to reduce sequentially the complicity configuration by combining appropriate series and parallel branches of the reliability model until the single equivalent element remains. This equivalent element then represents the reliability (unreliability) of the original configuration. [1]

PATH TRACING METHOD (P.T.M)

Complex system, such as substation or (switching station) are points of interconnection between of transmission, sub transmission and distribution systems. The most suitable method for quantifying their ability to perform this function is to calculate the frequency and duration of their failure to do so.

In the previous discussion it has been assumed that the minimal cut sets can be identified from a visual inspection of the system. In simple systems, visual identification can normally be an accomplished with little difficulty. The problem of identification becomes more difficult for larger and more complex systems and there is a method to deduce MCSs can be implemented on a digital computer this method is called Path tracing method.

The steps of this method as follows:

1- Deduce all minimal paths.

2- Construct an incidence matrix that identifies all components in each path.

3- If all elements of any column of the incidence matrix are non zero the component associated with that column forms a first order cut.

4- Combine two columns of incidence matrix at a time if all elements of the combined columns are non zero, the components with those columns form a second order cut. Eliminate any cut containing first order cuts to give a second order MCS.

5- Repeat step (4) with three columns at a time to give the third order cuts, this time eliminating any cut containing first and second orders MCS.

6- Continue until maximum order of the cut has been reached. [4]

Reliability Evaluation Of Iraqi West North Region Network Using P. T. M

The study of reliability has been investigated with more extension in power systems, in the field of purely electrical engineering such as the reliability studies on transmission and distribution.

Quantitative reliability and safety analysis are important for analyzing system design, demonstrating compliance with safety requirements, justifying system changes or additions, and optimally upgrading system safety and reliability. In this study I'm take analysis reliability of 400 KV Iraqi super grids (west north region).

Figure (3) shows a (400 kv for west north region). Iraqi electrical national grid consists of 400 KV super grid and 132KV ultra high voltage for electrical power transmission, while for distribution purpose, the voltage level 33kv and 11kv system.

DATA OF FAILURE AND REPAIR RATE

The data of power stations (failure and repair rate) are obtained from establishment of generation and production of electrical energy (G.E.E.P) from planning section. For the transmission lines the failure rate is considered (0.0014f/yr/km) and the mean outage duration of transmission lines are considered 12 hours. **Table (1)** gives the failure rate, repair rate and mean dead time of each component in 400 KV super grids.

CUT SETS DEDUCEMENT

From the analysis of 400KV of west north region shown in **Figure (3)** we can deduce the following paths which shown in **Table (2).**

1- {1+2+3+4}
2- {6+7}
3- {1+2+3+5+7}
4- {4+5+6}

RELIABILITY EVALUATION OF WEST NORTH REGION OF 400KV IRAQI SUPER GRID

Primary Event Failure Calculations

We can find Primary Event Failure Rate by using Failure Rate and Mean dead time found in **Table (3)** as input information

ā (1)= failure rate (1) × dead time (1)

= 1.7276E-4 × 45.154

= 0.780081E-2

$\bar{r}$ **(1)**= Failure Rate × t

= 1.7276E-4t

By the same way we found all other element of Primary Event Failure Rate

Minimal Cut Sets Failure Calculations

By using minimal cut sets shown in **Table (4, and 5)** finding unavailability, unreliability and failure rate:

For (1,6) :

Ā= ā(1) ×ā(6)

= 0.780081E-2 × 0.3048E-3

= 0.2377687E-5

$\bar{R}$ = **[ā(6)** failure rate (1)+ **ā(1)** × failure rate (6)] t

= [0.3048E-3 × 1.7276E-4 + 0.780081E-2 × 25.4E-6]t

= [2.50797822E-7]t

$\Lambda = \sum[\textit{failure rate} \times \bar{a}]$

= 1.7276E-4 × 0.3048E-3 +25.4E-6 × 0.780081E-2

= 2.50797822E-7

By the same way we find all other elements

System Failure Calculations

Finally finding the value of all of Iraqi west north region network

$$\overline{A}_t = \sum \overline{A}$$

$$\overline{R}_t = \sum \overline{R}$$

$$\Lambda_t = \sum \Lambda$$

$$MTF_t = 1/\sum \Lambda$$

The reliability and unreliability of the system for 8760 hour

(One year) are evaluated; R+Q=1

R_1 =1-Q

=1- 8.442327524E-6

= 0.9999

R_2 =1- 1000Q

R_3 =1- 2000Q, the results of system are shown in **Table 6**

CONCLUSIONS AND RECOMMENDATIONS

1- By the differential equation of Reliability calculating the Reliability of West North Iraqi of 400Kv , from this results the Reliability increasing if the distance is decreasing. After developing and analyzing the results of the present:

2- Useful to assess reliability and availability indices of 132 KV Iraqi network. This represents high tension to transfer electrical power from generation regions to distribution regions, using Path Tracing Method.

3- Study and evaluate the reliability characteristic of the 400 KV Iraqi network by applied the fault tree analysis, Markov process and Path Tracing Method, and compare the results of these methods to deduce the optimum method for reliability analysis.

REFERENCES

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2) Glossary of Terms "North America Electric Reliability Council " August (1996).

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Table (1) Input Information

Component number	Component name	Failure Rate hr^{-1}	Repair Rate hr^{-1}	Mean dead time(hour)
1	M.M.D.	1.7276E-4	2.2146E-2	45.154
2	2*63 km	6.7E-6	0.1666	6
3	2*184 km	19.604E-6	0.1666	6
4	250km	40.735E-6	0.083	12
5	159 km	25.4E-6	0.083	12
6	Paji P.s	36.862E-4	0.1522	6.5685
7	27 km	4.593E-6	0.083	12

Table (2) Adjacent Matrix for 400KV West North Iraqi

Path No.	Components						
	1	2	3	4	5	6	7
P_1	1	1	1	1	0	0	0
P_2	0	0	0	0	0	1	1
P_3	1	1	1	0	1	0	1
P_4	0	0	0	1	1	1	0

Table (3) :The Minimal Cut Sets

ORDER	MINIMAL CUT SETS
1st order	Nil
2nd order	{1,6},{2,6},{3,6}
3rd order	{1,5,7}{2,5,7}{3,5,7}{4,5,7}

Table (4) Primary Event Failure Information

Primary Event	$\bar{a}$	$\bar{r}$
1	0.780081E-2	1.7276E-4t
2	0.402E-4	6.7E-6t
3	0.117624E-3	19.604E-6t
4	0.48882E-3	40.735E-6t
5	0.0242128	36.862E-4t
6	0.3048E-3	25.4E-6t
7	0.55116E-4	4.593E-6t

Table (5) Minimal Cut Sets Failure Information

MCS_S	Ā	$\overline{R}$	Λ
1	0.2377687E-5	2.50797822E-7t	2.50797822E-7
2	0.1225296E-7	2.04318108E-6t	2.04318108E-6
3	0.35852E-5	5.9782865E-6t	5.9782865E-6
4	0.104103E-5	15.95860377E-8t	15.95860377E-8
5	0.536474E-6	1.020503441E-8t	1.020503441E-8
6	0.1569707E-5	0.006314018E-8t	0.006314018E-8
7	0.523364E-5	0.207909658E-9	0.207909658E-9

Table (6) Results of Reliability and Unreliability versus Time

Time (hour)	Reliability R	Unreliability Q
1	0.9999	8.442327524E-6
1000	0.99156	8.44232E-3
2000	0.983115	16.884655E-3
3000	0.97467	25.326982E-3
4000	0.966231	33.76931E-3
5000	0.957788	42.211637E-3
6000	0.949346	50.653965E-3
7000	0.940904	59.096292E-3
8000	0.932461	67.53862E-3

Figure (1): Two components series system

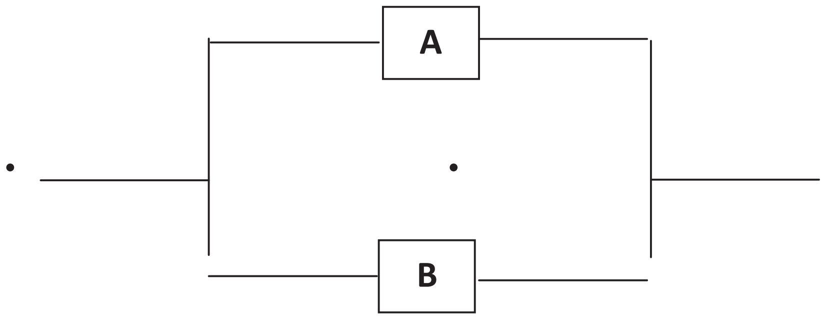

Figure (2): Two components parallel system

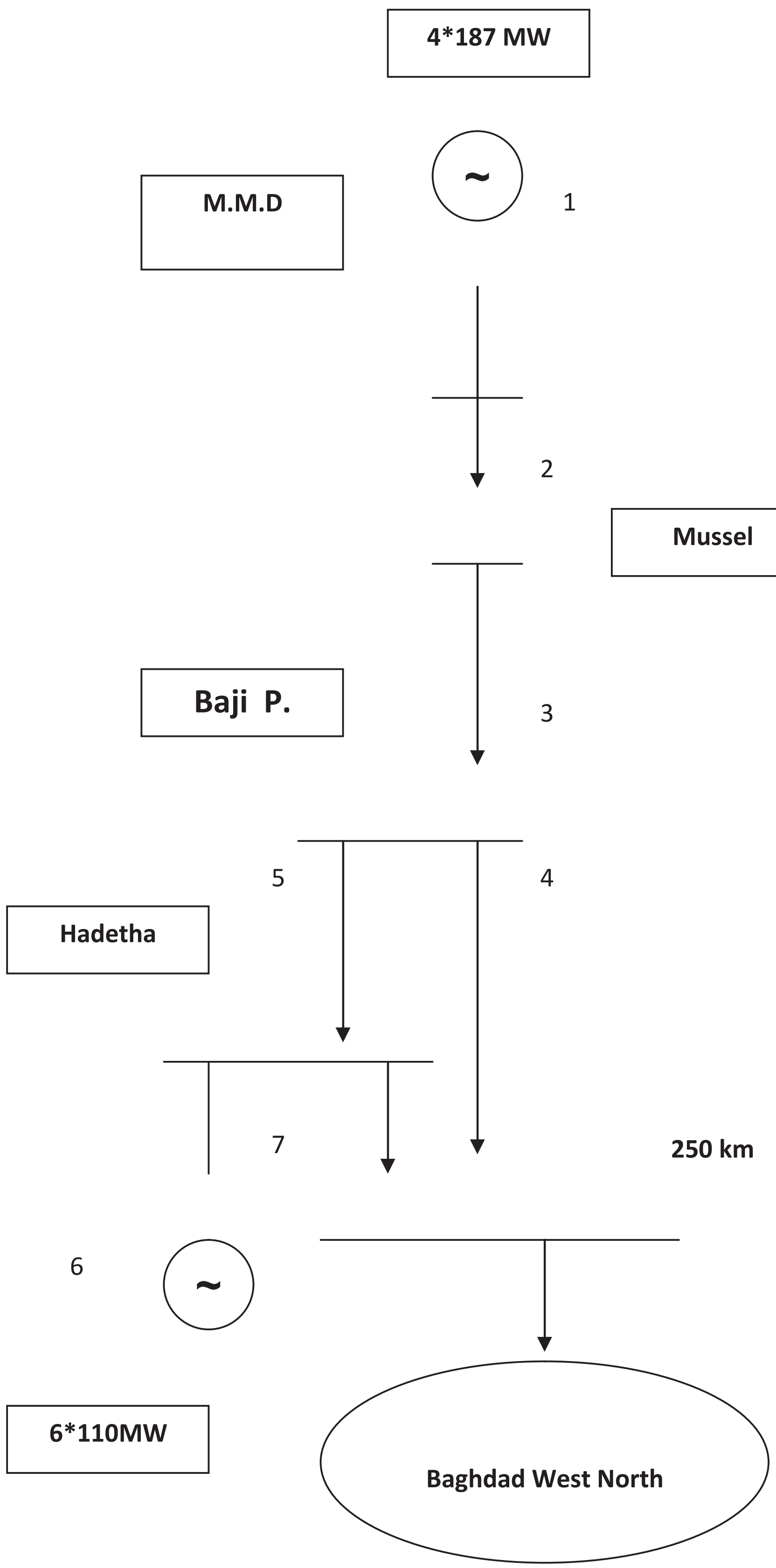

Figure (3): Single line diagram 400kv of west north region of Iraq