A computer Code for Relaiability Assesment of Electrical Auxiliary System Using Fault Tree Analysis

A. A. Fatah and **A. Z. Sadik**
Department of Electrical Engineering
Engineering College
Salahadin University - Erbil

ABSTRACT

The paper describes a code for analyzing different structures of electric power supply systems from the reliability point of view.

A general program (program -AA) is developed for finding the minimal cutsets from the fault tree of supply system and then evaluating the system unavailability as a function of the most significant minimal cutsets and the unavailability of primary events appearing in these critical sets for any complex auxiliary electric supply system. The program is implemented on IBM compatible Personal computer by using database software /Foxpro 2.6 . The results obtained from the model give a powerfull tool for the designer of supply systems from safety point of view .

INTRODUCTION

Generating stations comprise rather complex systems and expertise is required to maximize reliability and availability whilst minimizing costs , both capital and running .

This paper is concerned with the electrical auxiliary system which ,although only one part of the station , is a vital part , and is difficult to assess owing to its complexity of alternative connections.

Electrical auxiliary systems consist broadly of three parts : the main, the 'guaranteed' and the 'essential' supplies. The main supply feeds pumps,motors,fans,mills conveyers ,compressors ,lighting etc., depending on the type of fuel used .If failures occur in this supply, the unit is tripped. The 'guaranteed' supply feeds computers and instruments (which are expected to continue to function during large system disturbances, unit starting ,shutdown etc.) with a supply guaranteed quality .The essential supply system comprises standby generators and associated electrical connectors and drives ,and is generally used for the safe operation and post-trip cooling of nuclear stations ,and for dead-station start of fossil-fired stations . An estimate of the reliability of all of the three systems is necessary , e.g. if the

'guaranteed' system fails the station is shut down ,even if the generating system itself is perfectly healthy .
If a failure of any of these systems causes loss of the output,this loss must be made up by running less efficient plant . Spinning spare generation must be provided ready to take up such loads .This leads to an increased cost which can be evaluated once the effect of the auxiliary supply failures on the output of the station has been established.
Many computer codes are developed for finding unavailability of engineering systems .(1,2,3,4,5)
The present paper describes a computer code for evaluation the availability of supply system based on fault tree techniques .

THE METHOD

The fault distribution is assumed to be exponential , the elements are non-repairable , and the fault events are considered to be independent which is reasonable for this case .
The causal relations can be developed by fault trees ,which are then analyzed both qualitatively and quantitatively .
The qualitative analyzes of the fault tree includes finding minimal cutsets .The proposed algorithm based on the fact that as one proceeds down from the top event ,passing through an AND gate will invariably increase the size of a cutset while passing through an OR gate will invariably increase the number of cuts , not ,as a rule , all possible cuts but included will be all the minimal cuts , it is then a simple matter to identify these .
Quantitative analysis of the fault tree include obtaining the actual estimates of the probabilities of the occurrence of the top events from the probabilities of the basic events .Once all minimal cutsets are identified ,the system failure probability can be calculated from :

$$Q_{sys} = \sum_{i=1}^{n} Q_{ci} \quad \ldots\ldots\ldots(1)$$

Where Q_{sys} is the failure probability of the system , Q_{ci} is the failure probability of the ith minimal cutset and n is the total number of the minimal cut sets :

$$Q_{ci} = \prod_{j=1}^{m} Q_j \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where : Q_j is the failure probability of component j (basic event) , m is the number of elements of cut set i.

Algorithm

Step 1: Draw the fault tree for the supply system .
Step 2 : write the structure matrix for the fault tree .
Step 3 : find the minimal cut sets according to the flowchart shown in fig.(1) .
Step 4 : find the minimal cut set failure probabilities using equation 2 then the system failure probability using equation 1 .

NUMERICAL RESULTS

Two examples are considered ,the system of fig.(2) and the system of fig.(4) [5] . The primary event data is given in table (1) . Fig.(3) is the fault tree of the scheme of fig.(2) and fig.(5) is the fault tree of the scheme of fig.(4) .

The structure matrices of the schemes of fig.(2) and fig.(4) are deduced from the fault trees from fig.(3) and fig.(5) and given in tables (2) and (3) respectively .
The results of running the program are given in tables (4) and (5) .

Table(1) , event probability data . [6,7]

No.	Component	Q
1	Lines	0.090
2	Transformers	0.100
3	Breakers	0.020
4	Busbars	0.024
5	Generators	0.100

Note : Different data have been chosen according to our engineering judgment from different known references.

Table(2), The structure matrix of system of fig(2)

G01R00	E10001	G03R02	E01003	G06R05	E03006
0	E11001	G04R02	E02003	G07R05	E04006
0	E12001	0	E06004	0	E05006
0	G02A01	0	G05A04	0	E07007
0	0	0	0	0	E08007
0	0	0	0	0	E09007

Table (3), The structure matrix of the system of fig(4).

G01R00	E13001	E01002	E10009
0	G02A01	E06002	E12009
0	G03A01	E11003	E03010
0	G04A01	G09R03	E04010
0	G05A01	E01004	E05010
0	G06A01	G10R04	E07011
0	G07A01	G11R04	E08011
0	G08A01	E06005	E09011
0	0	E02005	E11012
0	0	G12R05	E14012
0	0	E11006	E03013
0	0	E02006	E04013
0	0	G13R06	E05013
0	0	E12007	E07014
0	0	E14007	E08014
0	0	G14R07	E09014
0	0	E10008	E07015
0	0	E14008	E08015
0	0	G15R08	E09015

Note : R represents an OR gate , A represents an AND gate , E represents a basic event.

CONCLUSION

The algorithm described can be applied efficiently by the electrical engineer to make comparison between the design of different auxiliary supply systems from the safety point of view and to assign the weak points (which are the lower order cutsets) in each system .The work is considered to be the basic for the future development and accurate studies , where the algorithim can be extended to include other gates. The results showed that the system of example(2) is better than that of example(1) from the safty point of view.

It was found that the adoption of data-base software will be, effectively , a good approach to carry out our aims in standardization and future expansions .Also this approach permits the utilization of the power of new database versions.

REFERENCES

1. Dr. Nihad Al-rawi , A. A. Fatah , M. A. F. Muhammad ,1989," A computer code for reliability assessment of electrical auxiliary systems " Proceedings Inter. AMSE conference "Signals and systems " , Brighton (U.K) , July 12-14, Asm press vol.7 p. 41-52 .

2. Bengiamin N.N. , B. A. Brown and K. F. Schenk, 1976 " An efficient algorithm for reducing the complexity of computation in fault tree analysis " IEEE trans. Nucl. Sci. Ns23 p.1442-1446 .

3. Fussel ,J. B. and W. E. Vesely ,1972, "A new methodology for obtaining cutsets for fault/trees " Trans. Am. Nucl. Soc. 15 p. 262-263 .

4. Fussel ,J. B.,1975, " How to hand –calculate system reliability characteristics " IEEE Trans. relaibility ,R-24,p.169-174.

5. Greliable.R-24 Garribba , S. 1977," Efficient construction of minimal cutset from fault trees " IEEE Trans. Reliab. R-26 ,p. 88-94.

6. A.G. Colombo , 1973, " A computer code for system availability and reliability evaluation", Report EUR 4940e.

Table (4) , Results of example (1) .

Record#	OT1	OT2	OT3	PROB.
1	10			0.090000
2	11			0.100000
3	12			0.024000
4	1	6		0.002400
5	2	6		0.000480
6	1	3	7	0.000040
7	1	3	8	0.000200
8	1	3	9	0.000040
9	1	4	7	0.000200
10	1	4	8	0.001000
11	1	4	9	0.000200
12	1	5	7	0.000040
13	1	5	8	0.000200
14	1	5	9	0.000040
15	2	3	7	0.000008
16	2	3	8	0.000040
17	2	3	9	0.000008
18	2	4	7	0.000040
19	2	4	8	0.000200
20	2	4	9	0.000040
21	2	5	7	0.000008
22	2	5	8	0.000040
23	2	5	9	0.000008

Fault probability of first order cutsets = 0.214

Fault probability of second order cutsets = 0.002880

Fault probability of third order cutsets = 0.002352000

Overall fault probability of the system = 0.219232000

Table (5) , Results of example (2)

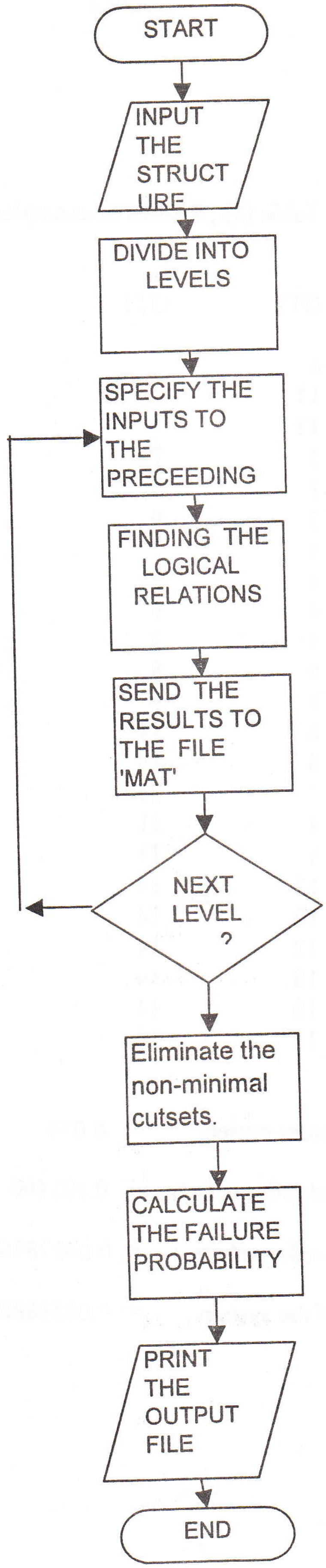
Record#	OT1	OT2	OT3	PROB.
1	13			0.024000
2	1	6		0.002400
3	10	11		0.009000
4	11	12		0.010000
5	1	3	7	0.000040
6	1	3	8	0.000200
7	1	3	9	0.000040
8	1	4	7	0.000200
9	1	4	8	0.001000
10	1	4	9	0.000200
11	1	5	7	0.000040
12	1	5	8	0.000200
13	1	5	9	0.000040
14	2	6	11	0.000048
15	2	6	14	0.000010
16	2	3	11	0.000040
17	2	4	11	0.000200
18	2	5	11	0.000040
19	7	12	14	0.000040
20	8	12	14	0.000200
21	9	12	14	0.000040
22	7	10	14	0.000036
23	8	10	14	0.000180
24	9	10	14	0.000036

Fault probability of first order cutsets = 0.024

Fault probability of second order cutsets = 0.021400

Fault probability of third order cutsets = 0.002789600

Overall fault probability of the system = 0.048189600


START
INPUT THE STRUCT URE
DIVIDE INTO LEVELS
SPECIFY THE INPUTS TO THE PRECEEDING
FINDING THE LOGICAL RELATIONS
SEND THE RESULTS TO THE FILE 'MAT'
NEXT LEVEL ?
Eliminate the non-minimal cutsets.
CALCULATE THE FAILURE PROBABILITY
PRINT THE OUTPUT FILE
END

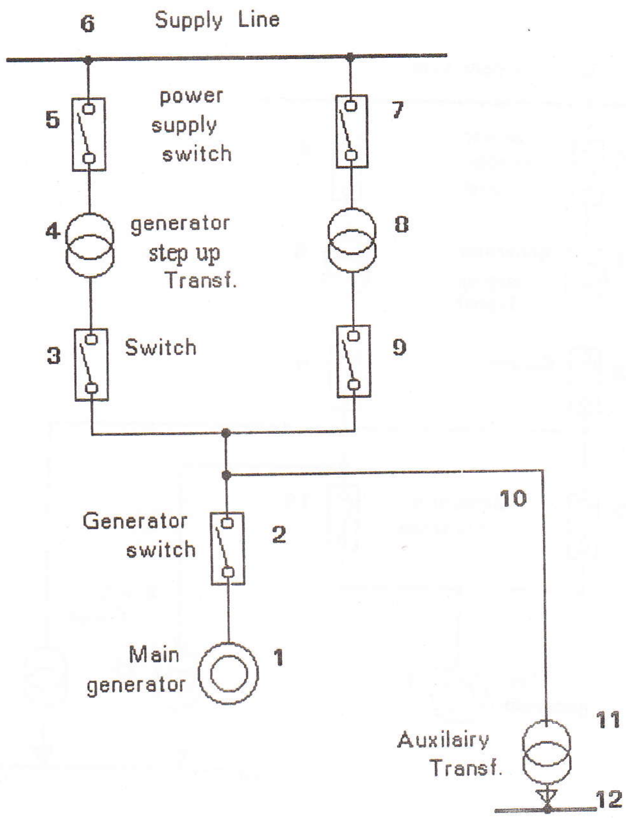


Fig. (2)

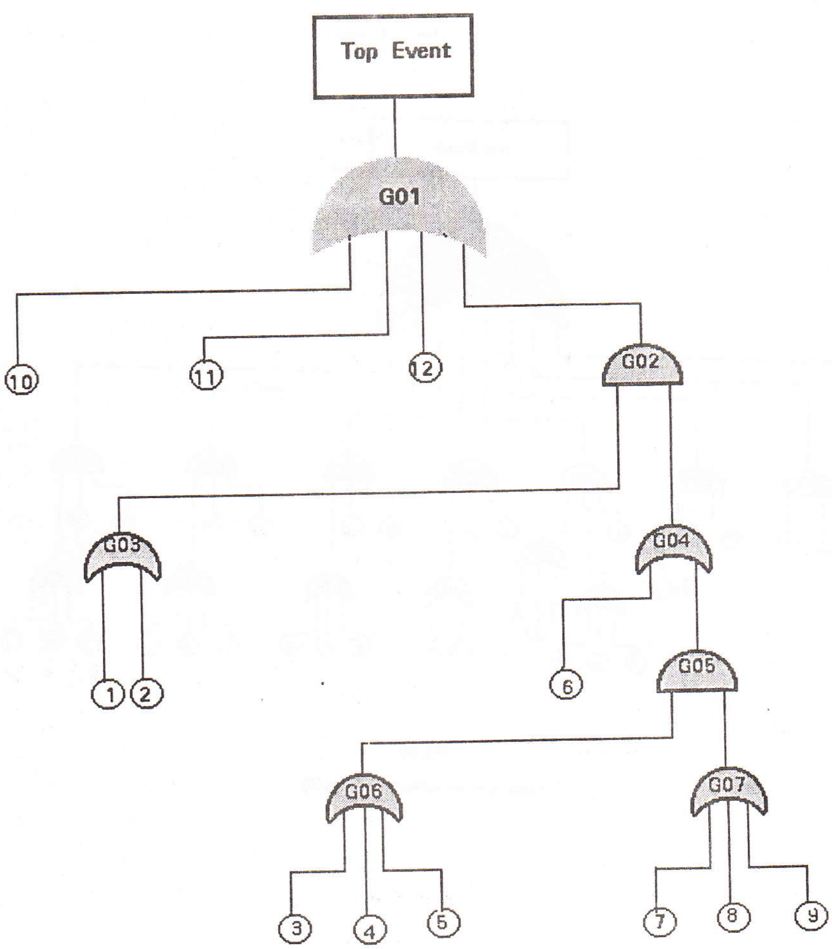


FIG.(3)

Fault tree of scheme of FIG.(2)

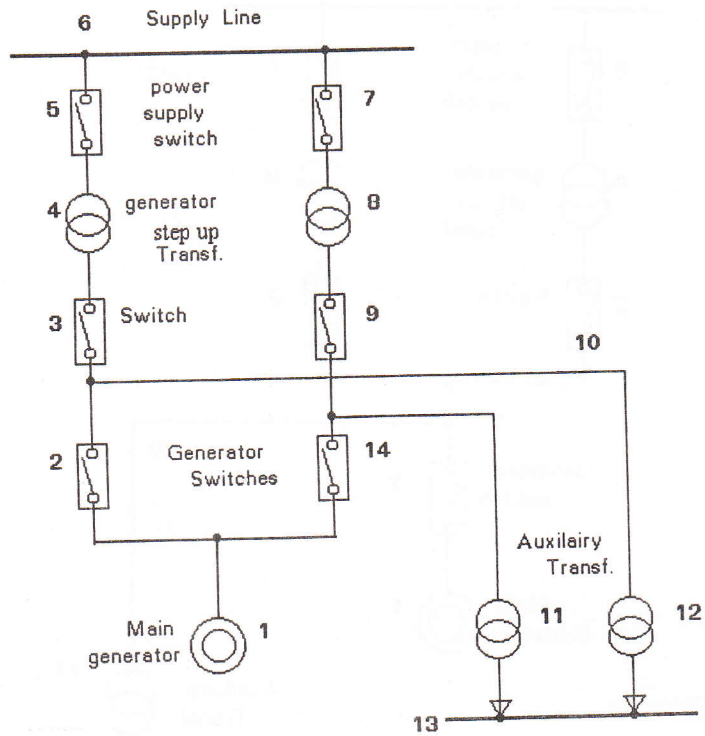


Fig. (4)

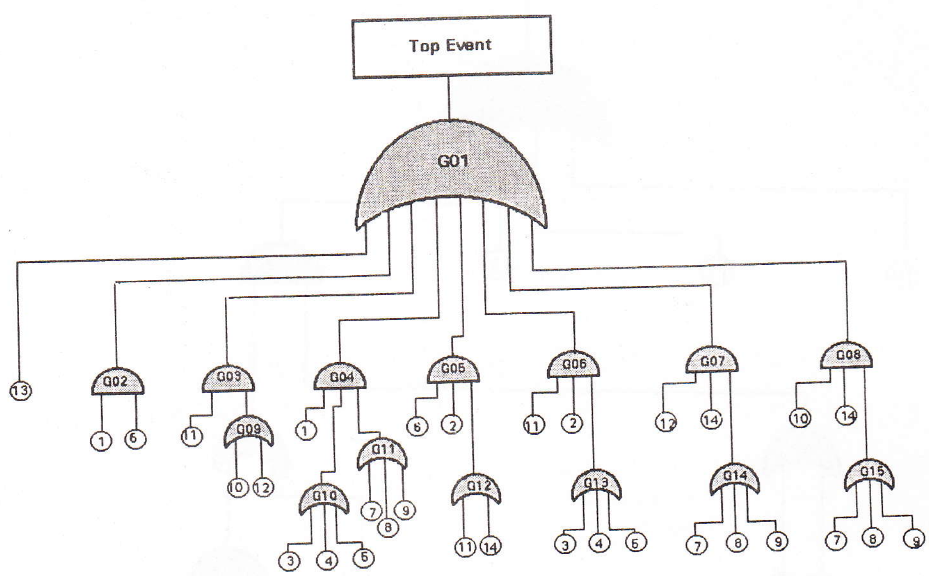


Fig.(5)

Fault tree of scheme of Fig.(4)

کۆدیکی کۆمپیوتەری بۆ هەلسەنگاندنی متمانەی ئامرازی سیستەمی کارەبا بەبەکارهینانی شیتەل کردنی درەختی هەلەکان

ئەمین عەباس و ئەمین زەکی
کۆلیجی ئەندازیاری – زانکۆی سەلاحەدین

کورتە

ئەم تویژینەوەیە لە کۆدیك دەکۆلیتەوە کە بۆ شیتەل کردنی سیستەمی وزەی کارەبا پیشنیار کراوە لە روانگەی متمانە پیکردنەوە.
پرۆگرامیکی گشتی نووسراوە بۆ دۆزینەوەی بچوکترین کۆمەلەی برانەکان لەدرەختی سەرچاوەی وزەی کارەباوە، جا هەلسەنگاندنی سیستەمەکە و لەکاربوونی وەکو نەخشەیەك بۆ گرنگترین کۆمەلەی برانەکان، هەروەها لەکارنەبوونی رووداوە سەرەتاییەکانیش لەو کۆمەلە شلۆقانە لەهەر سیستەمیکی ئالۆزی کارەباییدا. پرۆگرامەکە لەسەر کۆمپیوتەری IBM تاقیکراوەتەوە بەبەکارهینانی پرۆگرامی Foxpro 2.6 .

خوارزمية لحساب وثوقية منظومات التوزيع الكهربائية بأستخدام طريق شجرة الأخطاء

أمين عباس و أمين زكي
كلية الهندسة – جامعة صلاح الدين

الخلاصة

البحث أستنبط خوارزمية لتحليل مختلف منظومات التوزيع من ناحية الوثوقية. حيث تم وضع البرنامج A-A لأيجاد المجموعات الصغرى التي تسبب توقف الشبكة من شجرة الأخطاء وحساب وثوقية المنظومة كدالة لأهم المجموعات الصغرى وعدم جاهزية العناصر المكونة لهذه المجموعات.
تم تنفيذ البرنامج بحاسبة شخصية متوافقة IBM وبأستعمال قواعد المعلومات Foxpro 2.6. وبينت النتائج بأن البرنامج يشكل وسيلة مهمة لمصمم المنظومات من ناحية السلامة.