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REABILITY STUDY OF A POWER ELECTRIC ENERGY

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Abstract:

The paper treated the main aspects regarding the reliability of a power electric energy system from Electrica S.A.Reşiţa, with modern techniques for diagnosis and maintenance. It has been considered useful to treat the electric energy system with equivalent structural diagram method for reliability indicators calculus using the MathCAD medium.

Key words:
Reliability indicators, power system, equivalent structural diagram

1. INTRODUCTION

The issue concerning reliability indicators of power electric energy system 110 kV from S.C. Electrica S.A. Reşiţa, is structured on two parts: references at power system reliability analyses and convenience of maintenance based on reliability indicators calculus.

The reliability models used in electric power systems give the information regarding the behavior of the systems at the work rhythm and the options concerning the optimum network configuration.

The complex configuration of the 110 kV network, covering the county Caraş-Severin, implied application of the equivalent method based on reliability equivalent structural diagram.

2. THEORETIC CONSIDERATIONS

The large number of network nods 220/110 kV and 110 kV/medium voltage (20, 6kV) give some basis conditions. The 220 kV bars of 220/110 kV nod Soceni was similar with national electric power system (SEN) because of double connection with: Porţile de Fier electric plant and local network from Timişoara, which give the maximum reliability.

The sense of energy flux through cascade nods begin from node 1 and the whole network contends 21 nods.

In the elaboration of reliability equivalent structural diagram for every nod it was very important to know the critical conditions for the consumers strongly conditioned by the quality of electric energy and the risks implied by the undesired failures.

Under this circumstance there are the following consumers: mining industry (Anina and Moldova-Nouă), metallurgical industry (Combinatul Siderurgic Reşiţa and Oţelul Roşu), important industrial complex: UCM Reşiţa, ICM Bocşa, ICM Caransebeş, IPL Balta Sărată, IM Topleţ, electric injection nods of electric railway (CFR Caransebeş, CFR Poarta, CFR Topleţ) and urbane zones with important consumers (hospitals, public institutions, theatres, etc.)

The reliability calculus was made based on reliability indicators: faulting rate λ_i and repairing rate μ_i on equivalents elements (series or parallel), given in the technical literature [3,4]. For λ and μ values was used the national normative regarding the maintenance equipment and installation (transformers, circuit breakers, separator, power line etc.) depending on voltage level. The notation for voltage level was as follow: 220kV noted with 1, 110kV noted with 2 and medium voltage (20, 6kV) noted with 3.

For each nod the calculus of equivalent reliability indicator was made with MathCAD medium, and can be modified for new configuration of networks.

3. CALCULUS EXAMPLE

A calculus example is given as follow and it show the results for electric station of Soceni 220/100 kV from Reşiţa (nod 1).

Station 220/110 kV Reşiţa nod 1

$\lambda L1 := 0.55\cdot10^{-6}$ | $\lambda B1 := 1.47\cdot10^{-6}$ | $\mu L2 := 6.14\cdot10^{-2}$

$\mu L1 := 6.137\cdot10^{-2}$ | $\mu AT1 := 0.06\cdot10^{-2}$ | $\lambda L2 := 1.47\cdot10^{-6}$

$\mu I1 := 4.23\cdot10^{-2}$ | $\lambda AT1 := 20\cdot10^{-6}$ | $\mu IO2 := 6.78\cdot10^{-2}$

$\lambda I1 := 4.26\cdot10^{-6}$ | $\mu B2 := 19.9\cdot10^{-2}$ | $\lambda IO2 := 2.1\cdot10^{-6}$

$\mu S1 := 9.68\cdot10^{-2}$ | $\lambda B2 := 1.47\cdot10^{-6}$

$\lambda S1 := 0.39\cdot10^{-6}$ | $\mu S2 := 4.64\cdot10^{-2}$

$\mu B1 := 19.9\cdot10^{-2}$ | $\lambda S2 := 0.44\cdot10^{-6}$

$$\lambda a := \lambda B1 + 4.5\cdot\lambda S1$$

$$\lambda b := \lambda I1 + \lambda S1$$

$$\lambda a = 3.225\cdot 10^{-6}$$

$$\lambda b = 4.65\cdot 10^{-6}$$

$$\mu a := \frac{\lambda a}{\left(\frac{\lambda B1}{\mu B1}\right) + \left(\frac{4.5\cdot\lambda S1}{\mu S1}\right)}$$

$$\mu b := \frac{\lambda b}{\frac{\lambda I1}{\mu I1} + \left(\frac{\lambda S1}{\mu S1}\right)}$$

$$\mu a = 0.126385835566107$$

$$\mu b = 0.044396432443776$$

$$\lambda c := 9\cdot\lambda I1 + 18\cdot\lambda S1$$

$$\mu c := \frac{\lambda c}{\left(\frac{9\cdot\lambda I1}{\mu I1}\right) + \left(\frac{18\cdot\lambda S1}{\mu S1}\right)}$$

$$\lambda c = 4.536\cdot 10^{-5}$$

$$\mu c = 0.046337553720344$$

$$\lambda A := 2\cdot\lambda a + \lambda b + \lambda c$$

$$\mu A := \frac{\lambda A}{\left(\frac{2\cdot\lambda a}{\mu a}\right) + \left(\frac{\lambda b}{\mu b}\right) + \left(\frac{\lambda c}{\mu c}\right)}$$

$$\lambda A = 5.646\cdot 10^{-5}$$

$$\mu A = 0.049758698282387$$

$$\lambda d := \lambda AT1 + \lambda I1 + \lambda S1 + \lambda IO2 + 2.5\cdot\lambda S2$$

$$\lambda d = 2.785\cdot 10^{-5}$$

$$\mu d := \frac{\lambda d}{\frac{\lambda AT1}{\mu AT1} + \left(\frac{\lambda I1}{\mu I1}\right) + \left(\frac{\lambda S1}{\mu S1}\right) + \frac{\lambda IO2}{\mu IO2} + \left(\cdots\right.}$$

$$\mu d = 8.318297533520635\cdot 10^{-4}$$

$$\lambda e := \lambda IO2 + \lambda S2$$

$$\mu e := \frac{\lambda e}{\left(\frac{\lambda IO2}{\mu IO2}\right) + \left(\frac{\lambda S2}{\mu S2}\right)}$$

$$\lambda e = 2.54\cdot 10^{-6}$$

$$\mu e = 0.062783933622478$$

$$\lambda f := \lambda B2 + 5.5\cdot\lambda S2$$

$$\mu f := \frac{\lambda f}{\frac{\lambda B2}{\mu B2} + \left(\frac{5.5\cdot\lambda S2}{\mu S2}\right)}$$

$$\lambda f = 3.89\cdot 10^{-6}$$

$$\mu f = 0.065331917029837$$

$$\lambda g := \lambda B2 + 4\cdot\lambda S2$$

$$\mu g := \frac{\lambda g}{\frac{\lambda B2}{\mu B2} + \left(\frac{4\cdot\lambda S2}{\mu S2}\right)}$$

$$\lambda g = 3.23\cdot 10^{-6}$$

$$\mu g = 0.071274155928574$$

$$\lambda h := \lambda B2 + 9.5\cdot\lambda S2$$

$$\mu h := \frac{\lambda h}{\frac{\lambda B2}{\mu B2} + \left(\frac{9.5\cdot\lambda S2}{\mu S2}\right)}$$

$$\lambda h = 5.65\cdot 10^{-6}$$

$$\mu h = 0.057964685543116$$

$$\lambda i := 15\cdot\lambda IO2 + 37.5\cdot\lambda S2$$

$$\mu i := \frac{\lambda i}{\frac{15\cdot\lambda IO2}{\mu IO2} + \left(\frac{37.5\cdot\lambda S2}{\mu S2}\right)}$$

$$\lambda i = 4.8\cdot 10^{-5}$$

$$\mu i = 0.058521939309383$$

$$\lambda B := \lambda d + \lambda f + \lambda g + \lambda e$$

$$\mu B := \frac{\lambda B}{\frac{\lambda d}{\mu d} + \left(\frac{\lambda f}{\mu f}\right) + \left(\frac{\lambda g}{\mu g}\right) + \left(\frac{\lambda e}{\mu e}\right)}$$

$$\lambda B = 3.751\cdot 10^{-5}$$

$$\mu B = 1.115514986348169\cdot 10^{-3}$$

$$\lambda Bd := \lambda B\cdot\frac{\lambda d\cdot(\mu B + \mu d)}{\mu B\cdot\mu d + \lambda B\cdot\mu d + \lambda d\cdot\mu B}$$

$$\mu Bd := \mu B + \mu d$$

$$\mu Bd = 1.947344739700232\cdot 10^{-3}$$

$$\lambda Bd = 2.054459714754358\cdot 10^{-6}$$

$$\lambda D := \lambda h + \lambda i$$

$$\mu D := \frac{\lambda D}{\frac{\lambda h}{\mu h} + \frac{\lambda i}{\mu i}}$$

$$\lambda D = 5.365\cdot 10^{-5}$$

$$\mu D = 0.058462749425833$$

$$\lambda E1 := \lambda A + \lambda Bd + \lambda D$$

$$\mu E1 := \frac{\lambda E1}{\frac{\lambda A}{\mu A} + \frac{\lambda Bd}{\mu Bd} + \frac{\lambda D}{\mu D}}$$

$$\lambda E1 = 1.121644597147544\cdot 10^{-4}$$

$$\mu E1 = 0.036096383963777$$

The notations from calculus example correspond to the reliability equivalent structural diagram given in figure 1, made in normal function regime of electric station.

The method replace the power system bars and the consumers in successive steps with more simple diagrams until one element noted E_1^1 respective E_2^1 (superior indices represented the nod number and the inferior indices the system number). The normal regime function of nod is reliability equivalent with series diagram of elements E_1^1 and E_2^1, respective element E^1.

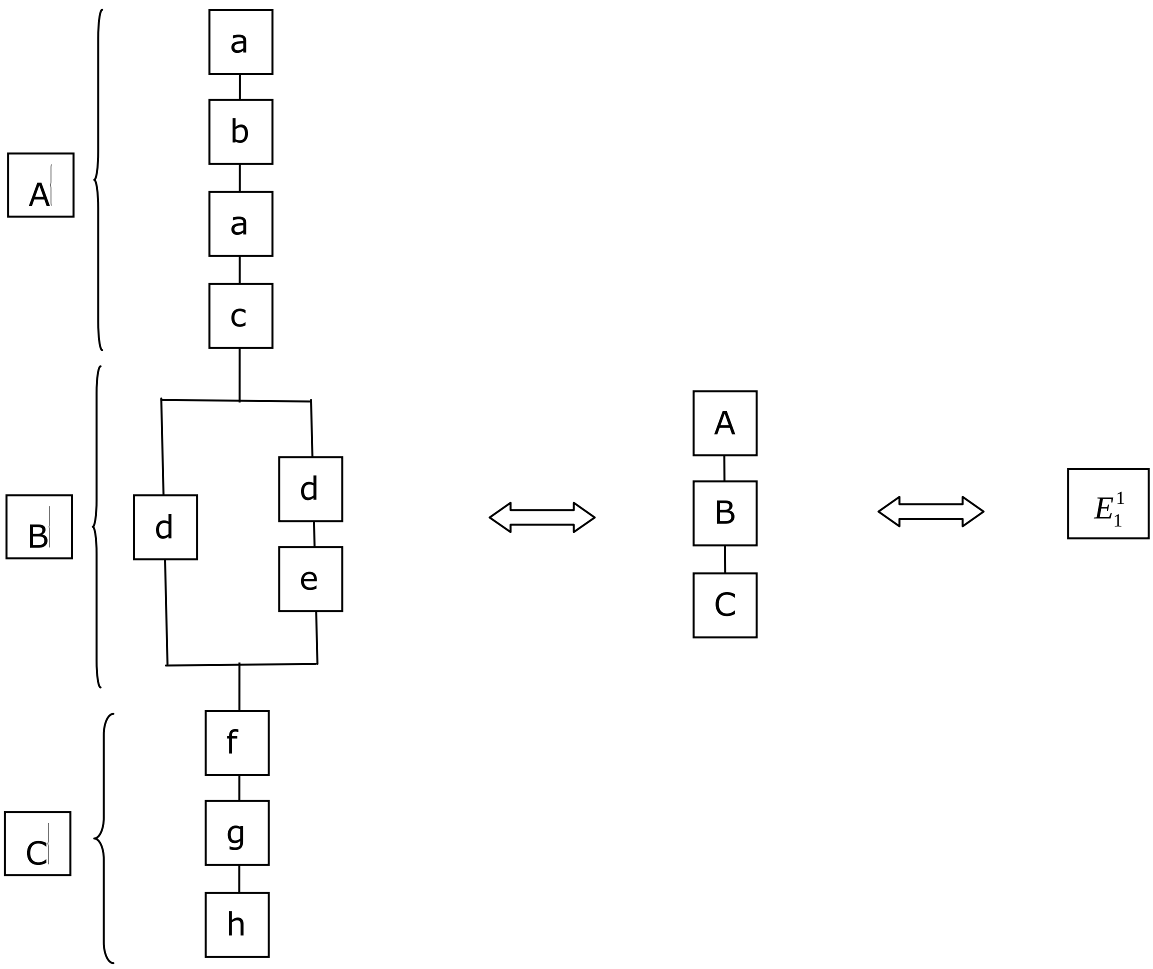

Fig.1.a.

Fig.1. *Equivalent calculus diagrams. a. System I; b. System II*

Based on calculated values for equivalent faulting rate λ_{Ei} and equivalent repairing rate μ_{Ei} (i=1, 21) for the 21 nods, was calculated the reliability indicators calculus: probability of function and failure, mean value of yearly time function and for ten years, respective of failure and medium number of failures on yearly time and on ten years time function.

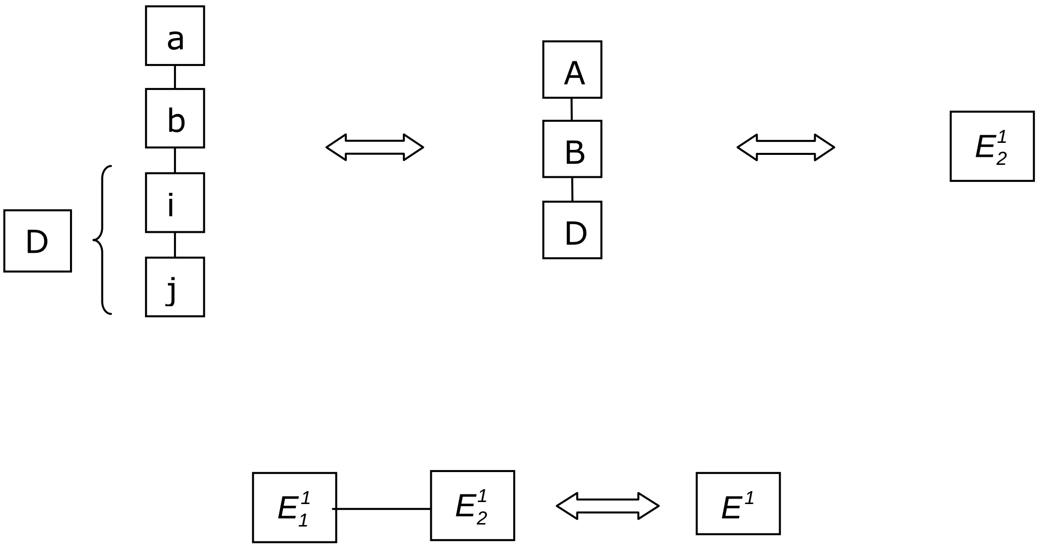

Fig.1.b.

It was also used the MathCAD medium and for Station Soceni 220/110kV, respective nod 1, for exemplification the results are given in table 1.

Table1*.Value of reliability indicators for nod 1*

Indicator	Value
Mean value of yearly time function (t =8760 h)	8,733x10^3 (h)
Mean value of function for ten years (t =8760 h)	8,733x10^4 (h)
Mean value of yearly time failure (t=87600h)	27,136 (h)
Mean value of failure for ten years (t=87600h)	271,362 (h)
Medium number of failures on yearly time function	0,98
Medium number of failures on ten years time function	9,795

4. CONCLUSIONS

The reliability indicators for actual network give for every nod the basis dates for the realistic assessment of electric power systems performances such as: quality and continuous delivering of energy, availability and functional flexibility. It is obvious that for "zero degree" consumers an own electric power sources is required.

The paper gives a dynamic model of reliability indicators calculus using the MATHCAD medium, which can be change for any new configuration of network or nods diagrams of power electric energy system 110 kV from S.C. Electrica S.A. county Caras-Severin.

5. BIBLIOGRAPHY

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