Journal of Theoretical and Applied Information Technology

www.jatit.org

MARKOV METHOD BASED RELIABILITY ASSESSMENT OF EHT TRANSMISSION SYSTEM IN CHITTOOR DISTRICT OF ANDHRA PRADESH STATE IN INDIA

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ABSTRACT

This paper proposes an application of Markov model based reliability assessment for EHT Transmission system involving 132 kV & 220 kV level voltages in Chittoor District

INDEX TERMS

O&M - Operation and Maintenance
MTTF - Mean time to failure
MTTR - Mean time to repair
EHT - Extra High Tension

ACRONYMS

Λ - Average failure rate
μ - Repair rate
A - Availability
U - Unavailability
r - Repair time
f - Outage frequency
T_{ui} - ith operating duration
T_{di} - ith outage duration
N - Number of outages

I INTRUDUCTION

An important issue in today's deregulated utility environment is reliability. Customers demand high level of service and desire the lowest possible cost. In order for utilities to remain competitive, they need to maintain high level of reliability while keeping the capital as well as O&M costs down. Computation of main indices such as A, U, λ, μ etc is essential for efficient maintenance scheduling and budget planning. A chronological failure history of Transmission system is collected and based on this data, reliability indices are determined. The procedure adopted in [1] & [2] is directly applied to the transmission network of a province for availability assessment of EHT Transmission network

II MARKOV MODELS

The Transmission Line failure process can be modeled as a two-state Markov process with constant failure and repair rates i.e. transition rates. We assume that the occurrences of such failures are independent with their own failure and repair rates.

The differential equations that govern transitions for Transmission Line failures between the normal and failure statuses are as follows.

$$\frac{d\mathbf{p}_x(t)}{dt} = \mathbf{p}_x(t)\mathbf{A}_x \quad \text{--------} \quad (1)$$

Where $\mathbf{p}_x$ (t) is the row vector that contains normal and failure status probabilities (i.e. p_x (t) and q_x (t))

$$\mathbf{p}_x(t) = [p_x(t), q_x(t)] \quad \text{------} \quad (2)$$

Also $p_x(t) + q_x(t) = 1$ ------ (3)

Where $0 \le p_x(t) \le 1$ and $0 \le q_x(t) \le 1$

In addition $\mathbf{A}_x$ is the transition intensity matrix i.e.

$$A_x = \begin{bmatrix} -\lambda_x & \lambda_x \\ \mu_x & -\mu_x \end{bmatrix} \quad \text{-------} \quad (4)$$

The initial condition represents the probability of normal status set to one and the probability of failure status set to zero.

$$\mathbf{p}_x(0) = [1 \;\; 0]$$

The solution to the above differential equations gives the probabilities of normal and failure statuses

$$p_x(t) = \frac{\mu_x}{\lambda_x + \mu_x} + \frac{\lambda_x}{\lambda_x + \mu_x}\exp\left(-\left(\lambda_x + \mu_x\right)t\right)$$

$$q_x(t) = 1 - p_x(t)$$

$$q_x(t) = \frac{\lambda_x}{\lambda_x + \mu_x} - \frac{\lambda_x}{\lambda_x + \mu_x}\exp\left(-\left(\lambda_x + \mu_x\right)t\right) \quad \text{--------} \quad (5)$$

If only long term status probabilities are of interest, the normal and failure status probabilities are expressed as following

$$p_x(\infty) = \frac{\mu_x}{\lambda_x + \mu_x} \quad \text{-------} \quad (6)$$

$$q_x(\infty) = \frac{\lambda_x}{\lambda_x + \mu_x}$$

III CALCULATION OF RELIABILITY INDICES

The reliability indices are calculated using the following formulae.

$$A = \frac{\sum_{i=1}^{N} T_{ui}}{\sum_{i=1}^{N} \left(T_{ui} + T_{di}\right)} \quad \text{-------} \quad (7)$$

$$U = \frac{\sum_{i=1}^{N} T_{di}}{\sum_{i=1}^{N} \left(T_{ui} + T_{di}\right)} \quad \text{-------} \quad (8)$$

$$\lambda = \frac{N}{\sum_{i=1}^{N} T_{ui}} \quad \text{------} \quad (9)$$

$$r = \frac{\sum_{i=1}^{N} t_{di}}{N} \quad \text{------} \quad (10)$$

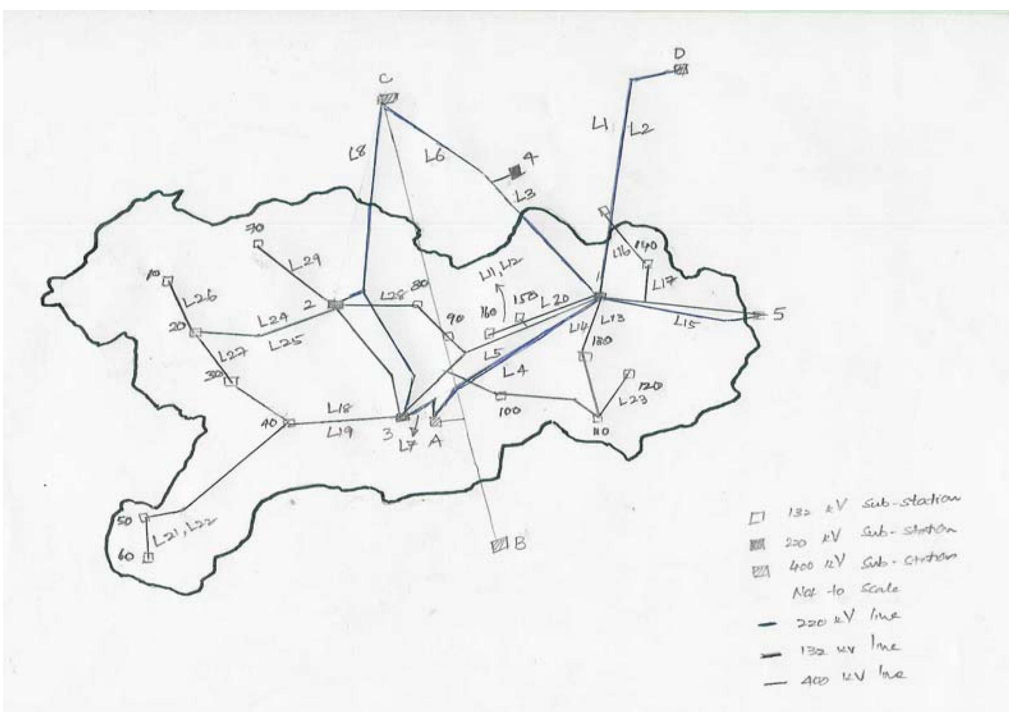
$$f = \frac{N}{\sum_{i=1}^{N} \left(T_{ui} + T_{di}\right)} \quad \text{-------} \quad (11)$$

Using the methodology described above, for each critical 132 & 220 kV feeder field data (i.e. number of outages and outage duration per year basis) is collected and Availabilities are computed.

IV DATA COLLECTION AND CALCULATION

The following tables show the details of calculations carried out for 132 kV (Table – A) and 220kV (Table – B) levels of the chosen network. At 132kV level 19 Nos. and at 220kV level 8 Nos. critical feeders are considered for the calculation of indices. The grid map (Fig – I) and associate Tables – I, II & III are as follows.

Final result is shown as follows (Table-C). The availabilities are arrived at based on the formulae explained in the previous sections. These quantitative values of Availability are essential for reliability and risk assessment of EHT Transmission network.



A CALCULATIONS FOR 132 KV FEEDER TRIPPING (TABLE-A)

Collected Data				Calculated Data			
Feeder Code	No. Of failures	Total outage duration in minutes	Total observed time in minutes	Total operating duration	MTTF	MTTR	Unavailability
L11	2	319	525600	525281	262640.5	159.5	0.00061
L12	3	320	525600	525280	175093.3	106.67	0.00061
L13	3	29	525600	525571	175190.3	9.67	0.00006
L14	7	159	525699	525441	75063	22.71	0.0003
L15	2	20	525600	525580	262790	10	0.00004
L16	5	2525	525600	523075	104615	505	0.0048
L17	3	45	525600	525555	175200	15	0.00009
L18	2	415	525600	525185	262592.5	207.5	0.00079
L19	2	50	525600	525550	262800	25	0.0001
L20	4	215	525600	525385	131346.3	53.75	0.00041
L21	1	25	525600	525575	525575	25	0.000048
L22	2	65	525600	525535	262767.5	32.5	0.000123
L23	2	71	525600	525529	262764.5	35.5	0.000014
L24	11	214	525600	525386	47762.4	19.45	0.000408
L25	12	214	525600	525386	43782.17	17.83	0.000407
L26	1	355	525600	525245	525245	355	0.000675
L27	2	58	525600	525542	262771	29	0.00011
L28	8	94	525600	525506	65688.25	11.75	0.000179
L29	2	48	525600	525552	262776	24	0.000091

B CALCULATIONS FOR 220 KV FEEDER TRIPPING (TABLE-B)

Collected Data				Calculated Data			
Feeder Code	No. Of failures	Total outage duration in minutes	Total observed time in minutes	Total operating duration	MTTF	MTTR	Unavailability
L1	8	406	525600	525194	65649.25	50.75	0.00077
L2	11	996	525600	524604	47691.27	90.82	0.0019
L3	5	288	525600	525312	105062.4	57.6	0.00055
L4	3	297	525699	525303	175101	99	0.00057
L5	1	75	525600	525525	525525	75	0.00014
L6	8	84	525600	525516	65689.5	10.5	0.00016
L7	2	30	525600	525570	262785	15	0.00006
L8	2	138	525600	525462	262746	69	0.00026

TABLE -C

Description	Availability(%)
132 kV Feeders	99.014
220 kV Feeders	99.559

TABLE - I

List of 132 kV Substations	
Code	**Name**
10	B.K. Kota
20	Madanapalli
30	Punganur
40	Palamaner
50	Santhipuram
60	Kuppam
70	Gurramkonda
80	Rompicherla
90	Pakala
100	K.P. Mitta
110	Nagari
120	Nagalapuram
130	Puthur
140	Srikalahasthi
150	Thirupati
160	Chandragiri

List of 220 kV Substations	
Code	**Name**
1	Renigunta
2	Kalikiri
3	Chittoor
4	Koduru
5	Sullurpet

List of 400 kV Substations	
Code	**Name**
A	Mahadevamangalam
B	Chennai
C	Chinakampalli
D	Manubolu

TABLE - II

List of 220 kV Feeders	
Code	**Description**
L1	Renigunta – Manubolu 1
L2	Renigunta – Manubolu 2
L3	Renigunta – Kodur
L4	Renigunta – Mahadevamangalam 1
L5	Renigunta – Mahadevamangalam 2
L6	Renigunta – Chinakampalli
L7	Chittoor – Mahadevamangalam 2
L8	Kalikiri - Chinakampalli

TABLE – III

List of 132 kV Feeders	
Code	**Description**
L11	Renigunta – Chandragiri 1
L12	Renigunta – Chandragiri 2
L13	Renigunta – Puthur 1
L14	Renigunta – Puthur 2
L15	Renigunta – Sullurupeta
L16	Srikalahasthi – Venkatagiri
L17	Renigunta – Srikalahasthi
L18	Chittoor – Palamaner 1
L19	Chittoor – Palamaner 2
L20	Renigunta – Tirupati
L21	Shanthipuram – Kuppam 1
L22	Shanthipuram – Kuppam 2
L23	Nagari – Nagalapuram
L24	Kalikiri – Madanapalli 1
L25	Kalikiri – Madanapalli 2
L26	Madanapalli – B.K. Kota
L27	Madanapalli – Punganur
L28	Kalikiri – Rompicherla
L29	Kalikiri – Gurramkonda

IV CONCLUSION

The procedure explained above is essential to find out the feeder tripping profile to plan preventive maintenance schedule. For efficient customer service, the feeder tripping number as well as interruption duration should be minimum. This study helps in the transmission network expansion planning also by identifying the frequently tripping feeders enabling the transmission company either by effective maintenance scheduling or by laying standby feeder network for minimizing electric supply interruptions.

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