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Application of Optimized Technique for Identification of Location and Recognition of Fault in Distribution System

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Abstract
Distribution network is the group of connected loads with number of buses and feeders. The different facial appearance is present in distribution system which makes it somewhat arduous and dissimilar to examine as estimated to a transmission system. Due to load uncertainties, the system effected with losses, faults, quality and discrepancies in power supply at distribution level. Now a days the identification of fault and its type as of conventional approaches is very complicated and calibrated dynamically is proposed in this work. This work narrates impedance-based fault calculation for its location and its type based on feeder distance between bus to bus for 3-phase 4-wire distribution system. The paper mix faults section detection with impedance-based method in order to address non-homogeneity of feeder parameters and power quality issues in distribution system. The 15-Bus and 33-Bus distribution test system is examined and estimated the fault and its type using Fuzzy logic using MATLAB.

Keywords
Radial Distribution System, Primitive Impedance Method, Load Flows, Fault Analysis, Fuzzy Logic System.

Introduction

From past decades, distribution system carrying a huge amount of power as compared to earlier because of increasing the per capital use of electricity. There are several changes in the era of electricity. Distribution system is connected at the end user side to supply power [1]. Due to some variations like load unbalancing, sudden intervention, and fault will occur in distribution network and it is affected to power quality issues. Almost 80% of fault chances to occur in distribution network.

Researcher's focusing on the special load flow technique based on topological attribute of distribution system for accurate analysis. Most of the techniques require for new data format or some data control. Recompense based approach is proposed [6] to solve the distribution load flow solutions. The impedance flow from starting end to which end you want the total end is called primitive impedance.

The severity of occurrence of faults at distribution side are Single line to ground fault-70-80%, Line-line to ground fault-10-17%, Line-line fault-8-10% and Three-phase faults-2-3%. There are lots of fault causes could lead to power damage, including the equipment failure, lightning, trees and so on. The fault is unavoidable in distribution system for many uncontrollable factors, such as animals, weather related factors, ice/snow, vehicles hitting transformers, improper installation. Fault location and type identification is very important problem in power system engineering in order to remove the fault quickly and recovery the power supply as soon as possible with minimum intervention. This is for protection of power equipment and customer satisfaction[7-10].

There are different types of loads in distribution system like domestic loads, commercial loads, and industrial loads. But, all loads can cause to event of faults as domestic loads which increase the electric load capacity, switching on loads with heavy start-up currents, event of over voltage and under voltages. In commercial loads and industrial loads the faults occur due to heavy loads.

By using primitive impedance based method this work finds the load flow calculations. After that it found fault impedance calculations will validate. The difference between affected impedance and nominal impedance will highlight the location of the fault.

Distribution Load Flow Calculations

By finding branch currents, it can calculate these active power and reactive power of a distribution systems, the current injection at bus i, the complex power Si is specified and the corresponding equivalent current injection at the k-th iteration of the solution is computed as shown in eq.1 and eq.2 [13-14]

$$S_i = V_i * I_i^* = P_i + jQ_i \qquad (1)$$

Where i= 1,2,3,……….n

In eq.1 which can take P is active power load and Q is a reactive power load. The equivalent current injection can be expressed as

$$I_i = \frac{P_i - jQ_i}{V_i} \tag{2}$$

Primitive Impedance Based Load Flow Analysis

In primitive impedance based method can find voltage, current and power loss.
Current can be calculated using the formula shown in eq.3

$$I = \frac{P - jQ}{V} \tag{3}$$

V=base voltage
Voltage can be calculated using the formula shown in eq.4

$$V_{ij} = Z_{ij}I_{ij} \tag{4}$$

In eq.4 the impedance can be taken as r and x in the given data Power loss can be calculated using formula shown in eq.5

$$P_{ij}= I_{ij}^2 * R \tag{5}$$

For the test system data can calculate load power voltage and loss power can calculate for all branches given in table.1 and the theoretical results can show in table.3

Algorithm of Primitive Impedance Based Load Flow Studies

Step1. Collect the data from distribution system.
Step2. Form the 'ipathse[i]', 'ipathre[i]' and 'pathline' vectors.
Step3. For the ith bus, add the impedances of all the lines that are stored in the 'pathline' vector that impedance is taken as primitive impedance
Step4. Initially take the Bus Voltages as V_i= 1+j0in p.u., for all buses.
Step5. Calculate the Power and Current at all the three phase buses.
Step6. Initially the iteration count can be taken as k=1.
Step7. Assign I[i]old = I[i] for all the three phase buses.
Step8. Using the vectors determined in the step2, calculate the [Δv] elements of the equation [Δv] = [DLF] [I].
Step9. Update the bus voltages at all the three phase buses. V[i] = V[i] +[Δv][i]
Step10. Calculate the current Injections I[i] with the bus voltages.
Step11. Print the converged three phase load flow solution and Stop.

Test System

In this paper the 15 bus and 33 bus distribution system data can be chosen and do load flow solutions for primitive impedance based method and do fault analysis for finding fault in distribution lines.

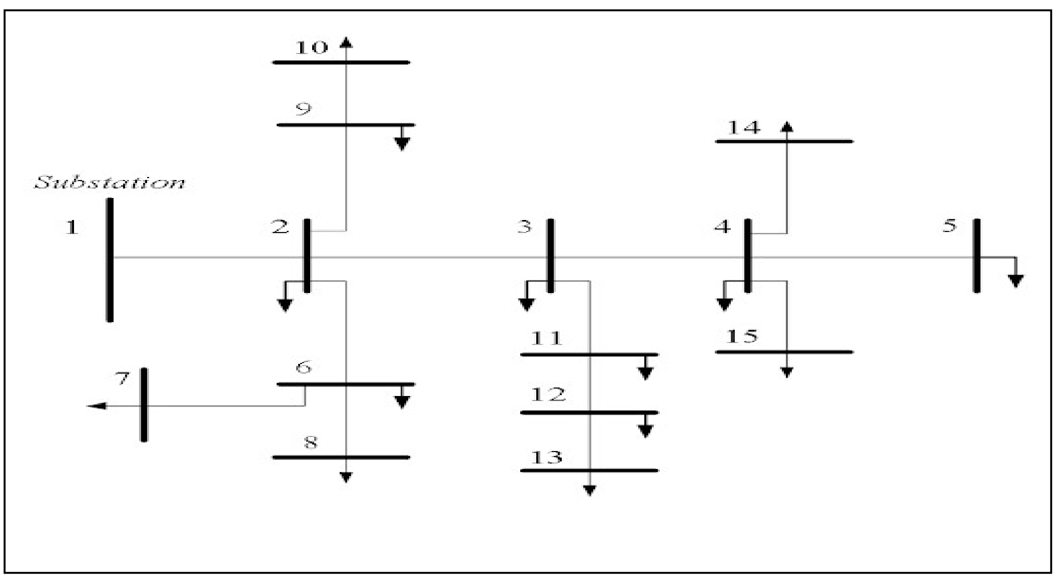

Fig.1: 15-Bus Distribution Sytsem

Table 1: 15- Bus Test System Practical Values for n Number of Iterations

Br	Se	Re	R (Ω)	X (Ω)	PL (kW)	QL (kVAR)	V (p.u)	LP (kW)	LQ (kVAR)	Pflow (kW)	Qflow (kVAR)	Primitive impedance (Ω)
1	1	2	1.35309	1.32349	50.40	37.80	0.97152	37.69	36.86	1463.36	1108.47	1.8927
2	2	3	1.17024	1.14464	80.00	60.00	0.95703	11.28	11.04	838.07	631.41	3.5297
3	3	4	0.84111	0.82271	160.00	120.00	0.95131	2.44	2.39	453.54	340.66	4.7063
4	4	5	1.52348	1.02760	50.40	37.80	0.95031	0.06	0.04	50.46	37.84	6.5439
5	2	6	2.55727	1.72490	160.00	120.00	0.95822	5.77	3.89	406.27	304.23	4.9773
6	6	7	1.08820	0.73400	160.00	120.00	0.95595	0.39	0.27	160.39	120.26	6.2899
7	6	8	1.25143	0.84410	80.00	60.00	0.95691	0.11	0.08	80.11	60.08	6.4868
8	2	9	2.01317	1.35790	80.00	60.00	0.96814	0.47	0.32	130.93	98.16	4.321
9	9	10	1.68671	1.13770	50.40	37.80	0.96705	0.06	0.04	50.46	37.84	6.3555
10	3	11	1.79553	1.21110	160.00	120.00	0.95018	2.18	1.47	293.25	219.72	5.6955
11	11	12	2.44845	1.65150	80.00	60.00	0.94598	0.60	0.41	131.07	98.25	8.6488
12	12	13	2.01317	1.35790	50.40	37.80	0.94464	0.07	0.05	50.47	37.85	11.0771
13	4	14	2.23081	1.50470	80.00	60.00	0.94897	0.20	0.14	80.20	60.14	7.3971
14	4	15	1.19702	0.80740	160.00	120.00	0.94880	0.44	0.30	160.44	120.30	6.1502

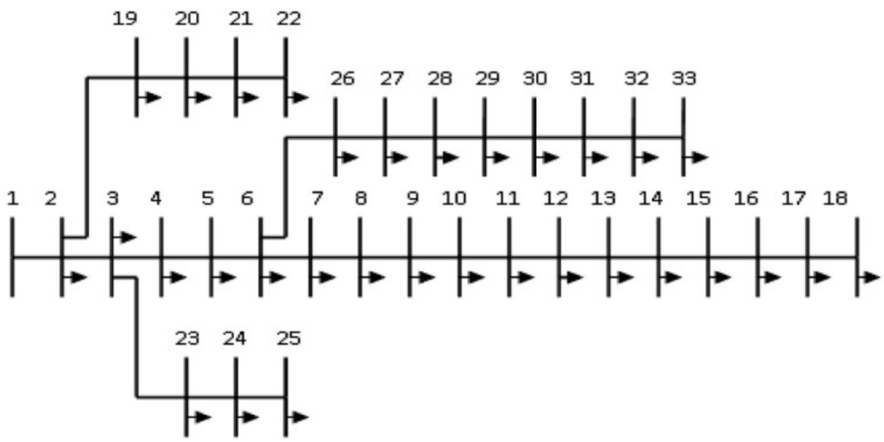

Fig.2: 33-Bus Distribution Sytsem

Table 2: 33-Bus Test System Results

Br	**Se**	**Re**	**R**	**X**	**P_L (kW)**	**Q_L (kVAr)**	**V (p.u.)**	**L_P (kW)**	**L_Q (kVAr)**	**Pflow (kW)**	**Qflow (kVAr)**
1	1	2	0.09220	0.04700	80.00	60.00	0.99764	7.27	3.70	3088.22	6.85
2	2	3	0.49300	0.25110	72.00	54.00	0.98670	30.12	15.34	2712.12	-53.65
3	3	4	0.36600	0.18640	96.00	72.00	0.98131	10.86	5.53	1859.29	-196.04
4	4	5	0.38110	0.19410	48.00	36.00	0.97601	10.17	5.18	1752.43	-193.57
5	5	6	0.81900	0.70700	48.00	36.00	0.96555	20.69	17.86	1694.27	-204.75
6	6	7	0.18720	0.61880	160.00	120.00	0.96338	1.30	4.31	873.99	147.35
7	7	8	0.71140	0.23510	160.00	120.00	0.95879	3.31	1.10	712.69	123.04
8	8	9	1.03000	0.74000	48.00	36.00	0.95326	2.89	2.08	549.37	101.95
9	9	10	1.04400	0.74000	48.00	36.00	0.94821	2.43	1.72	498.48	83.87
10	10	11	0.19660	0.06500	36.00	27.00	0.94741	0.37	0.12	448.06	66.15
11	11	12	0.37440	0.12380	48.00	36.00	0.94599	0.60	0.20	411.69	69.03
12	12	13	1.46800	1.15500	48.00	36.00	0.94065	1.85	1.46	363.09	67.83
13	13	14	0.54160	0.71290	96.00	72.00	0.93875	0.52	0.68	313.24	65.37
14	14	15	0.59100	0.52600	48.00	36.00	0.93729	0.29	0.26	216.72	72.69
15	15	16	0.74630	0.54500	48.00	36.00	0.93596	0.21	0.16	168.43	46.43
16	16	17	1.28900	1.72100	48.00	36.00	0.93413	0.19	0.25	120.22	30.28
17	17	18	0.73200	0.57400	72.00	54.00	0.93359	0.04	0.03	72.04	14.03
18	2	19	0.16400	0.15650	72.00	54.00	0.99718	0.12	0.11	288.83	56.79
19	19	20	1.50420	1.35540	72.00	54.00	0.99400	0.61	0.55	216.72	42.68
20	20	21	0.40950	0.47840	72.00	54.00	0.99340	0.07	0.09	144.11	28.13
21	21	22	0.70890	0.93730	72.00	54.00	0.99286	0.03	0.04	72.03	14.04
22	3	23	0.45120	0.30830	72.00	54.00	0.98357	2.21	1.51	750.70	113.06
23	23	24	0.89800	0.70910	336.00	252.00	0.97783	3.60	2.84	676.50	107.55
24	24	25	0.89600	0.70110	336.00	252.00	0.97497	0.90	0.70	336.90	52.70
25	6	26	0.20300	0.10340	48.00	36.00	0.96459	1.28	0.65	751.59	-385.97

26	26	27	0.28420	0.14470	48.00	36.00	0.96337	1.64	0.84	702.30	-397.62
27	27	28	1.05900	0.93370	48.00	36.00	0.96077	5.60	4.94	652.66	-409.46
28	28	29	0.80420	0.70060	96.00	72.00	0.95924	3.92	3.41	599.06	-430.39
29	29	30	0.50750	0.25850	160.00	120.00	0.95803	2.00	1.02	499.15	-435.81
30	30	31	0.97440	0.96300	120.00	90.00	0.95484	1.01	1.00	337.15	43.17
31	31	32	0.31050	0.36190	168.00	126.00	0.95419	0.13	0.15	216.14	22.17
32	32	33	0.34100	0.53020	48.00	36.00	0.95407	0.01	0.01	48.01	-3.99

Fault Analysis:

For finding fault current can use the formula shown in below[2-4]:

For Line to Ground fault

$$I_F = \frac{3V_F}{Z_1 + Z_2 + Z_0 + Z_f + Z_n} \quad (6)$$

For Line to Line fault

$$I_F = \frac{3V_F}{Z_1 + Z_2 + Z_f} \quad (7)$$

For double line to ground fault

$$I_F = \frac{3V_F}{Z_1 + Z_2 + Z_f + Z_n} \quad (8)$$

For three phase faults

$$I_F = \frac{3V_F}{Z_1 + Z_f + Z_n} \quad (9)$$

For finding fault voltage can calculate the formula as,

$$V_F = V + IZ \quad (10)$$

For finding fault location and type using the formula

$$Z_F = Z_{BF} + Z_{AF} \quad (11)$$

Where, Z_F=fault impedance, Z_{BF}=before fault impedance, Z_{AF}=after fault impedance

In this the fault location is identifies based on the distances were assumed and it segregated in table.3.

If the fault occur at the distance of 1km then the fault impedance is taken as Z_1 and the type of fault is defines on their fault current calculations as I_{1L-G}, I_{1L-L}, I_{1L-L-G}, $I_{1L-L-L}$and $I_{1L-L-L-G}$

Table 3: Location and Type of Fault Identification Based on Distance in km

Length in Km	Impedance representation(ohm)	Type of fault				
		L-G	L-L	L-L-G	L-L-L	L-L-L-G
2	Z2	I_{2L-G}	I_{2L-L}	I_{2L-L-G}	I_{2L-L-L}	$I_{2L-L-L-G}$
3	Z3	I_{3L-G}	I_{3L-L}	I_{3L-L-G}	I_{3L-L-L}	$I_{3L-L-L-G}$
4	Z4	I_{4L-G}	I_{4L-L}	I_{4L-L-G}	I_{4L-L-L}	$I_{4L-L-L-G}$
5	Z5	I_{5L-G}	I_{5L-L}	I_{5L-L-G}	I_{5L-L-L}	$I_{5L-L-L-G}$

Table 4: Branch Currents with and without Faults for 15-Bus System

Branch currents	Without fault	With faults at a distance of 3km variations at each bus				
		L-G	L-L	L-L-G	L-L-L	L-L-L-G
I_{12}	150.1712	4.4963	6.4493	5.6403	4.1012	3.771
I_{23}	84.1764	5.0899	6.0183	5.3819	4.4685	4.1122
I_{34}	51.179	4.114	4.3368	3.9273	3.5152	3.2420
I_{45}	5.727	9.5296	13.0738	11.4967	8.6328	7.9374
I_{26}	45.4512	0.1156	0.1209	0.1094	0.0978	0.0902
I_{67}	18.1808	3.7445	3.9041	3.5355	3.1646	2.9186
I_{68}	9.0896	5.8921	6.9191	6.192	5.1636	4.7523
I_{29}	14.8166	2.3713	2.8038	2.5073	2.0818	1.2772
$I_{9,10}$	5.727	0.4166	0.5799	0.5090	0.3782	0.3478
$I_{3,11}$	32.9974	1.2362	1.2891	1.1673	1.0448	0.9636
$I_{11,12}$	14.8166	21.711	25.4137	22.7507	19.0105	17.4968
$I_{12,13}$	5.727	2.7816	3.7977	3.3415	2.5177	2.3149
$I_{4,14}$	9.0896	18.8371	22.0600	19.7475	16.4964	15.1828
$I_{4,15}$	18.1808	5.2343	5.4507	4.9366	4.4219	4.0783

Fuzzy Logic System

Fuzzy logic system can be used to identify the fault. Fuzzy logic has so many benefits with simply defining and form several rules. Rules can be design based upon inputs and also used the membership functions. By using fuzzy logic system results can be obtained easily. The proposed work is that different inputs has different faults and based upon fault current can find type of fault and based upon fault impedance can identify location of fault. Classification of fault can be modeled as triangular membership function. Four inputs can be taken as four membership functions.

Table 5: Fuzzy Inputs

Type of Phase	Triplets		
	A	B	C
A	0	0.62	1.24
B	0.62	1.24	1.85
C	1.24	1.85	2.47
G	-0.5	0	0.5

By using the truth table triangular membership function can be assign and design SIMULINK for fuzzy system which can be taken as inputs is in truth table for different type of fault as different inputs.

Rules For Given Input:

(a) If line A is “near to 0.62” and line B is “near to 0” and line C is “near to 0” and line G is “near to 0” then the fault is “A-G”.

(b) If line A is “near to 0.62” and line B is “near to 1.24” and line C is “near to 0” and line G is “near to 1” then the fault is “A-B”.

(c) If line A is “near to 0.62” and line B is “near to 1.24” and line C is “near to 0” and line G is “near to 0” then the fault is “A-B-G”.

(d) If line A is “near to 0.62” and line B is “near to 1.24” and line C is “near to 1.85” and line G is “near to 1” then the fault is “A-B-C”.

(e) If line A is “near to 0.62” and line B is “near to 1.24” and line C is “near to 1.85” and line G is “near to 0” then the fault is “A-B-C-G”

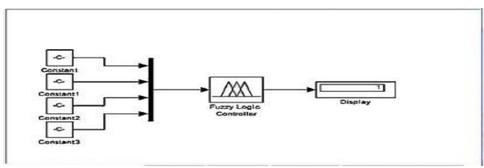

Fig. 3: SIMULINK for Fuzzy Logic Controller

By using this SIMULINK can easily identify the fault by adding the rules. This can be done for any test system as 15-bus and 33-bus. Fuzzy logic system can be easily identifying the fault.

Table 6: Fuzzy Outputs

Type of fault	Triplets		
	A	B	C
A-G	4	4.5	4.5
A-B	6	6.5	6.5
A-B-G	5	5.5	5.5
A-B-C	3.5	4	4
A-B-C-G	3.2	3.7	3.7

Conclusion

In three phase four wire distribution network the balanced and unbalanced load flows are proposed for solving the data with primitive impedance based for radial distribution network. The proposed method is accurate and fast result for finding fault location and its type for three phase four wire distribution network. Almost existing methods are taking some time but the proposed method used impedance based method is faster result. By using fuzzy logic system the fault current or fault impedance will declared with in a fraction of seconds. And it can use for both 15-bus and 33-bus data.

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