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Handling the Uncertainties in Hybrid Electric Power System

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Abstract

This paper mainly focused on uncertainty in power systems due to the penetration of renewable energy resources and consumer deviation. The focus is on making decisions for reasonable convencing choice an electric power generated by inductor/reactor that takes into account the uncertainties in wind farm generation and consumer requirement. To achieve this, the project proposes a stochastic optimization framework that uses an optimization-based representation to obtain optimal results. The proposed procedure is compared with popular evolutionary methods to assess its effectiveness in handling uncertainties and achieving optimal solutions. Overall, this project contributes to the literature on decision making in power systems under uncertain conditions. It provides a practical framework for power system engineers to make critical decisions on reactive power dispatch that can help prevent stability problems in the power system. uncertainties are disturbances in electrical power system. Where different kind of power generation plants are interconnected , then several problems araised. This paper presents uncertainities or disturbances of electrical power system when wind power generation plant is introduced.

Keywords: Hybrid electric power system, Distribution Generators, Reactive power Dispatch.

Introduction

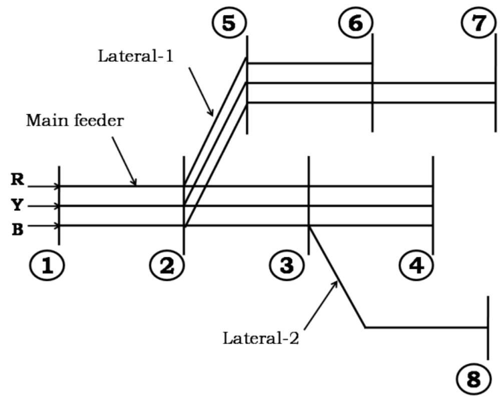
The development of power systems and the emergence of new energy concepts such as microgrids and smart grids have brought various challenges in scheduling and operating these networks. Modern power system scheduling can be performed for short, medium, and long-term periods, similar to conventional networks. However, accurate decision making for these periods is essential to manage the challenges of the power system. Decision making in power systems involves a range of problems related to different aspects such as scheduling, investment, and operation. Decision makers must consider all alternatives from cost, revenue, or risk perspectives. The primary goal is to ensure the safe, reliable, and cost-effective operation of the power system while meeting the demand for energy. To address these challenges, various optimization and decision-making techniques have been developed, including stochastic optimization, fuzzy logic, evolutionary algorithms, and machine learning. These techniques can assist decision makers in identifying optimal solutions and mitigating risks associated with the uncertainties in the power system. The handling of uncertainty is a critical issue for decision makers in power systems. Uncertain parameters can be classified into two categories: technical and economical parameters.Technical uncertaiparameters are related to the topology of the network, such as the failure rate of transmission lines or generators. Another technical uncertain parameter that affects operating decisions is the generation and demand value in the system.

Methodolgy:

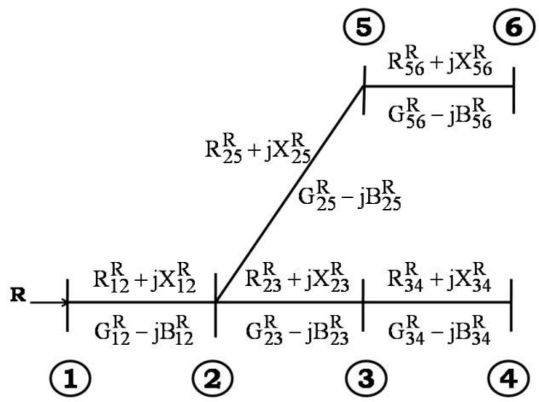
PRESENTEDPHASE-DECOUPLED LOAD FLOW METHOD

The mathematical computations to be followed to solve load flow problem using developed PDLF method, consider an URDS with 'N', 'nl' and 'p' denotes number of nodes, lines and unbalanced sections.

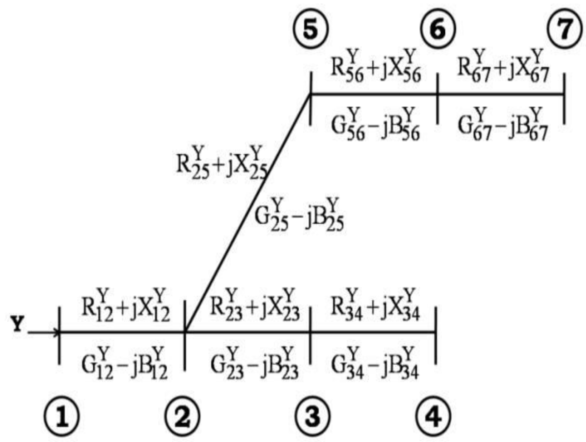
Numbering to the nodes is assigned starting from the substation node i.e., node-1 till the last node of the feeder. Then after, the numbering is continuous for the remaining nodes of the laterals joined to the main feeder. The diagram shown in Fig.2.2 describes the procedure following to assign numbers to the given distribution system.



Sample URDS with node numbers



for R-Phase



for Y-Phase

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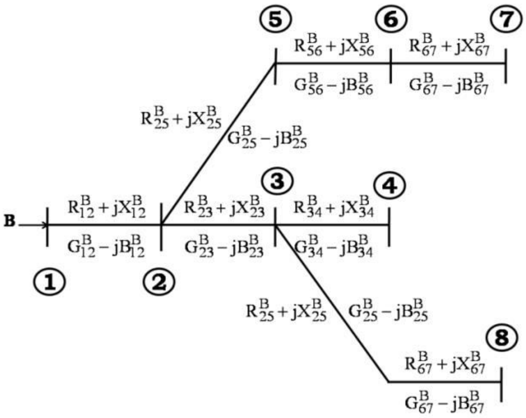


for B-Phase

Using the presented procedure, the size of the impedance matrix to be handled while solving load flow procedure is decreased to one element of six networks from nine elements of single network. To demonstrate this, consider a three-phase line connected in line 1 and 2 has nine impedance elements which include self and mutual impedance values. Whereas after decoupling, the single 3 × 3 matrix is divided into six 1 × 1matrix elements.

$$Z_{12}^{RYB} = \begin{bmatrix} Z_{12}^{RR} & Z_{12}^{RY} & Z_{12}^{RB} \\ Z_{12}^{YR} & Z_{12}^{YY} & Z_{12}^{YB} \\ Z_{12}^{BR} & Z_{12}^{BY} & Z_{12}^{BB} \end{bmatrix}$$

The above single matrix is decoupled into the following six individual elements for the calculation purpose in load flow solution procedure.

$$\left[Z_{12}^{RR}\right] ; \left[Z_{12}^{YY}\right] ; \left[Z_{12}^{BB}\right] ; \left[Z_{12}^{RY}\right] ; \left[Z_{12}^{RB}\right] ; \left[Z_{12}^{YB}\right]$$

To step by step procedure to be following to solve load flow problem is described as follows. For this procedure, the sending and receiving end nodes are represented with 's' and 'r' notations. Also, 'N' and 'nl' represents the total number of nodes and lines in a specifiedURDS.

Mathematical modeling of PDLF Method

Let us consider a line connected between 's' and 'r'nodes. Using conventional method, the voltage magnitude at node-r of R-phase can be mathematically expressed as

$$V_r^R = V_s^R - \left(I_{sr}^R \times Z_{sr}^R\right) - \left(I_{sr}^Y \times Z_{sr}^{RY}\right) - \left(I_{sr}^B \times Z_{sr}^{RB}\right)$$

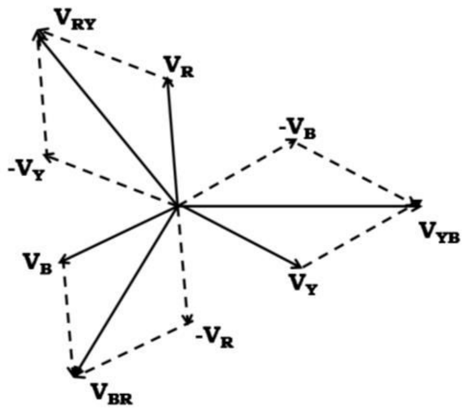
Where,

V_r^R , V_s^R are voltage magnitudes,

I_{sr}^R, I_{sr}^Y, I_{sr}^B are the line current flow in three phases,

'Z_{sr}^R, Z_{sr}^{RY} , Z_{sr}^{RB}' are the self and mutual impedances of line s-r.

The phasor representation for theabove expression for evaluating receiving end voltage is illustrated in Fig



Phasor representation to evaluate phase voltage

Here, in the presented load flow method, final voltage magnitude in R-phase at node-r can be achieved by adding the voltages achievedfrom R-phase self-impedance network, RY-phase and RB-phase mutual impedance networks. This can be mathematically expressed as

$$\begin{aligned} V_r^R &= V_s^R - \left(I_{sr}^R \times Z_{sr}^R\right) + V_s^{RY} - \left(I_{sr}^Y \times Z_{sr}^{RY}\right) + V_s^{RB} - \left(I_{sr}^B \times Z_{sr}^{RB}\right) \\ &= V_s^R - \left(I_{sr}^R \times Z_{sr}^R\right) + \sqrt{3}V_s^R \angle 30 - \left(I_{sr}^Y \times Z_{sr}^{RY}\right) + \sqrt{3}V_s^R \angle 210 - \left(I_{sr}^B \times Z_{sr}^{RB}\right) \\ &= V_s^R - \left(I_{sr}^R \times Z_{sr}^R\right) - \left(I_{sr}^Y \times Z_{sr}^{RY}\right) - \left(I_{sr}^B \times Z_{sr}^{RB}\right) + \sqrt{3}V_s^R \left[\left(\frac{\sqrt{3}}{2} + j\frac{1}{2}\right) + \left(\frac{-\sqrt{3}}{2} - j\frac{1}{2}\right)\right] \\ &= V_s^R - \left(I_{sr}^R \times Z_{sr}^R\right) - \left(I_{sr}^Y \times Z_{sr}^{RY}\right) - \left(I_{sr}^B \times Z_{sr}^{RB}\right) \end{aligned}$$

This procedure can be implied for the remaining two phases also. Using this method, the computational burden for solving three phase load flow problem is reduced drastically and the system.

Node	R-Phase (deg)		Y-Phase (deg)		B-Phase (deg)	
	Linear LF [47]	Presented PDLF	Linear LF [47]	Presented PDLF	Linear LF [47]	Presented PDLF
1	0.000	0.000	-120.000	-120.000	120.000	120.000
2	0.009	0.009	-119.988	-119.989	120.032	120.031
3	0.002	0.002	-119.991	-119.991	120.048	120.046
4	0.019	0.018	-119.982	-119.983	120.039	120.037

5	0.020	0.019	-119.983	-119.984	120.040	120.038
6	0.025	0.024	-119.978	-119.979	120.043	120.041
7	0.026	0.025	-119.979	-119.98	120.045	120.044
8	0.039	0.037	-119.967	-119.969	120.049	120.047
9	0.050	0.049	-119.949	-119.951	120.052	120.051
10	0.064	0.061	-119.924	-119.927	120.062	120.06
11	0.061	0.059	-119.919	-119.922	120.065	120.063
12	0.068	0.066	-119.922	-119.925	120.062	120.06
13	0.059	0.057	-119.912	-119.916	120.065	120.062
14	0.062	0.059	-119.918	-119.921	120.067	120.064
15	0.074	0.071	-119.916	-119.919	120.061	120.059
16	0.078	0.076	-119.919	-119.922	120.057	120.055
17	0.063	0.061	-119.92	-119.923	120.07	120.067
18	0.062	0.060	-119.917	-119.920	120.068	120.065
19	0.081	0.078	-119.917	-119.920	120.06	120.058

Comparison of voltage angles with presented PDLF method of URDS-19 node

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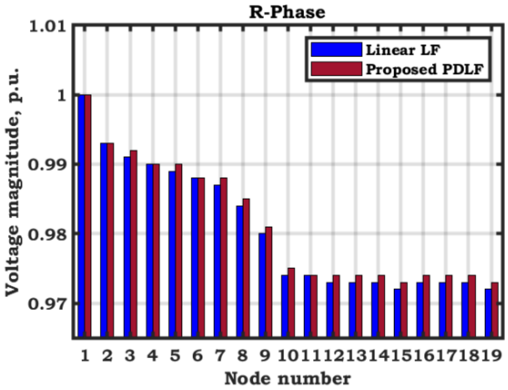
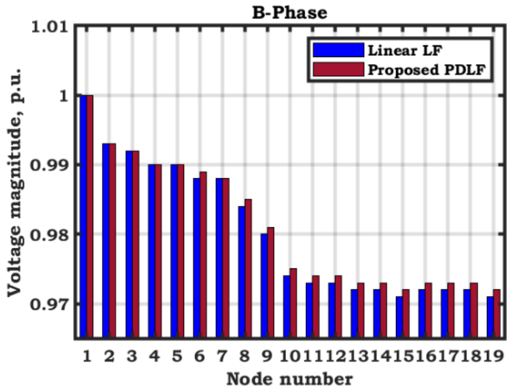
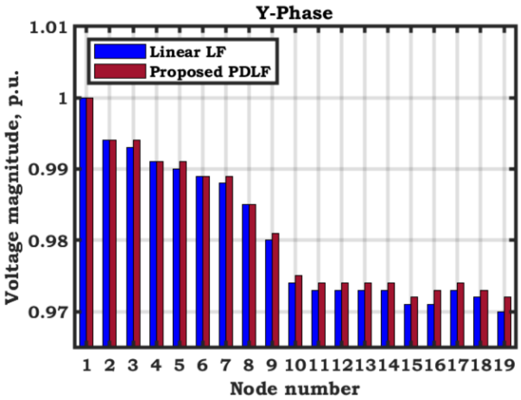




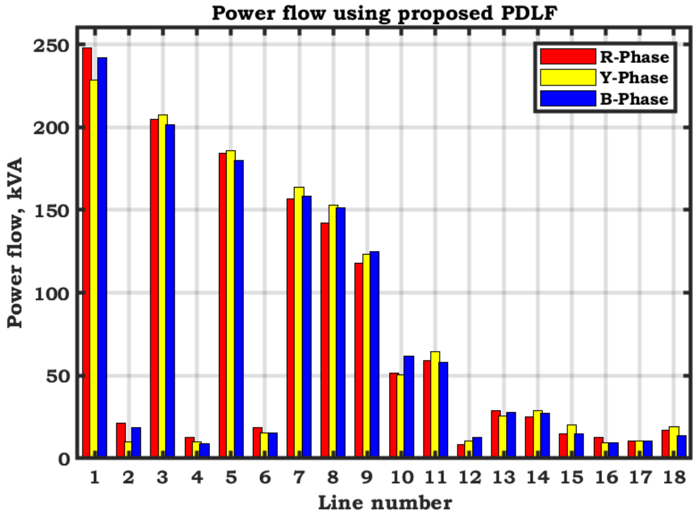


With presented PDLF method, power flow through each line for all phases is tabularized in Table.The respective graphs are represented in the figure.

Power flows with presented PDLF method of URDS-19 node

Line No	Supply end	free end	Power flow, kVA		
			R-Phase	Y-Phase	B-Phase
1	1	2	247.8452	228.5498	242.0135
2	2	3	21.21948	9.995364	18.72576
3	2	4	204.8939	207.1474	201.6709
4	4	5	12.48203	9.994367	8.715909

5	4	6	184.0284	185.6154	179.9033
6	6	7	18.71522	15.59817	15.59814
7	6	8	156.9017	163.7364	158.4000
8	8	9	142.0046	152.8118	151.2731
9	9	10	117.7605	123.4229	125.0381
10	10	11	51.51168	50.2048	61.50713
11	10	12	59.06263	64.38482	57.78377
12	11	13	8.438783	10.27721	12.4882
13	11	14	28.71951	25.57709	27.7638
14	12	15	25.32608	28.73714	27.16404
15	12	16	14.97816	19.98991	14.97832
16	14	17	12.48558	9.345459	9.345413
17	14	18	10.27622	10.27622	10.62516
18	15	19	16.86033	19.35203	13.74117



Conclusion:

This methodology works based on the concept of decoupling phases due to this, the computational burden, computational time, number of iterations and there by the computational space requirements have been reduced when compared to literature methods. The numeraryachieved with presented PDLF method have been tabularized and analyzed with supportive illustrations. From the results, it has been inferred that, the presented method gives better results when compared to existing literatureregarding parameters of the systemfor example voltage at nodes, power flow through distribution lines and power loss.

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