

Optimum-Location of PV in Distribution System using NR Method with Matlab-ETap Program

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Abstract—This paper presents a method for optimizing photovoltaic (PV) system placement in distribution systems using the Newton-Raphson (NR) method with MATLAB code and E-Tap program load flow analysis. The proposed approach utilizes MATLAB code to calculate the optimal location and size of PV systems for maximum Voltage Level and minimum power losses. E-Tap program load flow analysis is used to simulate the distribution system and to validate the results obtained from the MATLAB code. The study provides a detailed explanation of the methodology used for the optimization and validation process. The Newton-Raphson method begins with an initial estimate of the root, denoted $x_0 \neq x_r$, and uses the tangent of $f(x)$ at x_0 to improve on the estimate of the root. The expected outcomes include reduced power losses and improved Voltage Levels. The paper concludes with simulation results and a discussion of the potential benefits of the proposed approach. Also, we are working on analyses of the Kirkuk Power System (IEEE-5 Bus Bar). Find the Optimum Location and Size for the PV system in Kirkuk Power System (IEEE-5 BB). We use a PV system to improve the Voltage Level and reduce Losses in the Kirkuk Power System (IEEE-5 BB). Compare the power system before and after connecting the PV system using E-TAP and MATLAB software.

Keywords—NR method, PV, Distribution System, Optimum Location, MATLAB-ETAP.

1. INTRODUCTION

After more problems come from oil, such as pricing, pollution, etc., the world is searching for a new power source to increase the demand for renewable energy. Solar power is the number 1 energy source; it's free and clean.

Power system quality is essential to users; voltage level is a suitable flag for quality and losses decrease, and finally, the cost of power going too low. [1].

The power distribution system imports power from generation to supply, so power quality and voltage level are necessary to reduce losses and increase efficiency in all distribution systems [2].

To analyze the power system to get the state of the distribution system for solving voltage level and loss problems. Need mathematics model to analyze IEEE5bb system[3]. Many methods can be used for that, like Newton Raphson Method. This method finds approximate results for all parameters in the distribution system. Newton Raphson (NR) Method can find optimum results for the root of the best solution in the system as the following equation no. (1).

$$x_{K+1} = x_K - F'(x_K)/F''(x_K) \quad (1)$$

Where x is variable, K is constant, and f' is derivative of goal.

If x_k is the current guess for the minimum of the function, $f'(x_k)$ is the derivative of the function evaluated at x_k , and $f''(x_k)$ is the second derivative of the function evaluated at x_k . The iterative process is continued until the algorithm converges to a minimum of the function[4].

The Newton-Raphson method is an iterative optimization algorithm that can find the roots of a nonlinear equation or minimize a function.

The distribution system has many types of standards, like IEEE standards. This paper's problem is that Kirkuk City has the same IEEE5BB system.

Some busbars in the system voltage level are not in range and have more losses and energy costs that are very high, so using the PV system in the optimum place will help with all problems.

Finding the optimum location to connect PV is a problematic job [5]. Using NR will find the best root for the solution to get the analysis and reach the goal .

To fully complete this research needs a simulation of the distribution system IEEE5BB[6]. E-Tap software is the best app for building a full model and simulating it to get all parameters and load flow, and it helps forget actual data and a time system The Newton Method is used to find complex roots of polynomials and roots of systems of equations in several variables, where the geometry is far less precise. For more information about Pv, refer to the [7], [8].

2. NEWTON-RAPHSON METHOD FOR OPTIMUM PLACEMENT

The NR method is a numerical technique used to find the roots of a function. In optimizing the location of a PV (photovoltaic) system in a distribution system the NR method can be used to solve for the optimal location and size of the PV system based on specific constraints and objectives. This paper searches for the optimal placement of PV to solve the distribution system's voltage, losses, and cost problems[9].

Using NR has an objective function. Also, constraints in this work objectives include voltage improvement, losses decreasing, and finally, the total cost of power energy in the system [10].

Another objective is the size of PV to give exact reactive power to the system to reach the optimum voltage level.

To apply the Newton-Raphson method, we first need to define the objective function and constraints. For example, the objective function could be to minimize energy generation and distribution costs, while the constraints could be the maximum allowable voltage drop and the available space for installing the PV system.

Once the objective function and constraints are defined, the next step is to use the Newton-Raphson method to solve for the optimal location and size of the PV system. This involves iterative Jacobian matrix calculations and each iteration's objective function gradient until convergence is achieved.

The NRM is a powerful technique for solving optimization problems and analyzing power systems; it can be computationally intensive and requires careful selection of initial conditions to ensure convergence to a valid solution. Therefore, it is crucial to use appropriate software tools and consult with experienced professionals in the field when applying this method to optimize the location and size of a PV system in a distribution system.[18]. Several works for solving linear or non-linear equation can be found in [11].

3. METHODOLOGY OF WORK

The methodology for using the Newton-Raphson method to optimize the location of a PV system in a distribution system In numerical analysis, Newton's method, also known as the Newtown–Raphson method, is named after Isaac Newton and Joseph Raphson. The Newton-Raphson method to find the optimal value of $f(x)$ is equivalent to finding the critical points or ROOTS. so can be broken down into several steps, as follows:

1. Create a model of the distribution system in ETAP, including all the loads, generators, transformers, and other components. Assign appropriate load profiles and operating parameters to the loads and generators.
2. Define the PV system to be optimized, including its size and location. Assign appropriate performance parameters to the PV system, such as power output and efficiency.
3. Formulate the optimization problem as a mathematical equation in MATLAB that expresses the objective function as a function of the decision variables (such as the location and size of the PV system),[12]
4. Define the constraints on the optimization problem, such as voltage limits, power flow constraints, and other technical and physical constraints.
5. Use ETAP to run a load flow simulation of the distribution system with the PV system added in the initial location[13].
6. Calculate the Jacobian matrix of the power flow equations in MATLAB, which expresses the sensitivity of the power flow to changes in the voltage magnitudes and phase angles [14].
7. Select initial values for the decision variables that satisfy the constraints and are feasible for the optimization problem[15].
8. Use MATLAB to solve the optimization problem using the Newton-Raphson method iteratively. Calculate the Jacobian matrix and the objective function gradient at each iteration and update the decision variables using the Newton-Raphson equation.
9. Check for convergence of the optimization process by monitoring the change in the decision variables between iterations and comparing it to a predefined tolerance level[16].
10. Evaluate the optimized results using ETAP to run a load flow simulation with the PV system installed in the optimized location. Evaluate the performance metrics of the distribution system, such as voltage stability, power flow, and economic efficiency[17], [18].

4. RESULTS FOR (NR)

The outcomes of the program for determining the optimal placement of PV (Photovoltaic) systems in Kirkuk City, utilizing the IEEE 5-Bus System and employing the Newton-Raphson Method for the solution, are as follows:

Maximum Power Mismatch = 0.00052830

NO. OF ITERATIONS = 3

N o.	Mag.	Degree	MW	Mvar	MW	Mvar	Mvar
1	0.99	0.000	0.000	0.000	129.575	-7.570	0
2	0.98	-2.806	20.000	10.000	40.000	30.000	0
3	0.97	-4.997	45.000	15.000	0.000	0.000	0
4	0.98	-5.329	40.000	5.000	0.000	0.000	0
5	0.99	-6.150	60.000	10.000	2.400	0.000	0
Total			165.00	40.000	171.975	22.430	0
Bus	Volt.	Angle	-----Load-----		---Generation---		Injected

Line Flow and Losses

--Line--		Power at bus & line flow			--Line loss--	
from	to	MW	Mvar	MVA	MW	Mvar
1	2	129.575	-7.570	129.796		
2	3	88.864	-8.579	89.277	1.410	-2.431
3	4	40.723	1.158	40.739	1.192	-1.855
2	3	20.000	20.000	28.284		
1	3	-87.453	6.149	87.669	1.410	-2.431
3	4	24.694	3.546	24.948	0.352	-3.238
4	5	27.936	2.962	28.093	0.441	-2.966
5	4	54.823	7.343	55.313	1.125	0.176
3	1	-45.000	-15.000	47.434		
1	2	-39.531	-3.014	39.646	1.192	-1.855
2	3	-24.343	-6.784	25.270	0.352	-3.238
4	3	18.874	-5.202	19.578	0.036	-1.990
4	2	-40.000	-5.000	40.311		
2	3	-27.495	-5.928	28.126	0.441	-2.966
3	4	-18.838	3.212	19.110	0.036	-1.990
5	4	6.333	-2.285	6.733	0.031	-5.118
5	2	-60.000	-10.000	60.828		
2	4	-53.698	-7.167	54.174	1.125	0.176
4	5	-6.302	-2.833	6.910	0.031	-5.118
Out Losses \\\					2.587	-12.421

TABLE.1 RESULTS

Bus no.	Voltage (PU) by Without PV	Voltage (PU) with PV in the optimum location (NR)
1	0.95693529	0.99793439
2	0.94692279	0.99791940
3	0.92260437	0.99512988
4	0.90260678	0.99503430
5	0.80346583	0.99503438

Table no.1 shows the study's results on the effectiveness of implementing photovoltaic (PV) systems at the optimum location determined using the Newton Raphson method with MATLAB and E-Tap program. The study found that before implementing the PV system, Bus bar no. 5 had a shallow voltage level of 0.80346583 PU, significantly below the standard voltage level of 1 PU. This indicates that the distribution system was experiencing voltage instability, which could result in power quality issues and equipment damage[19].

However, after implementing the PV system at the optimum location, the voltage level on Bus bar no. 5 increased to 0.99503438 PU, much closer to the standard voltage level. This improvement in voltage level is significant and can lead to better power quality and more reliable operation of the distribution system[20].

The study also found that implementing the PV system positively impacted the voltage levels on other bus bars, with all bus bars showing a significant increase in voltage levels. This suggests that implementing PV systems can help maintain voltage levels in the distribution system, especially during high load demand[21].

In summary, our study demonstrates the importance of selecting the optimum location for PV implementation in the distribution system. Advanced techniques like the Newton Raphson method with MATLAB and the E-Tap program can aid in identifying the optimal location, leading to significant improvements in the voltage levels and overall system performance.

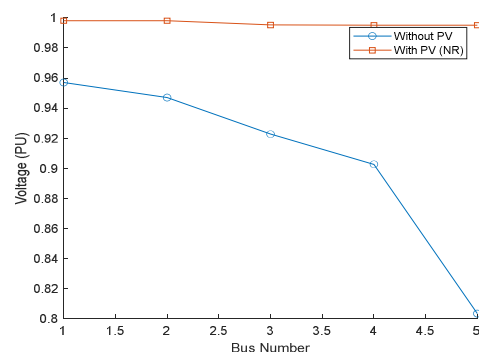


Fig.1 Voltage value in every bus bar before and after connecting PV

Figure no.1 shows the voltage value in every bus bar before and after connecting PV, as table no.1 mentions that the voltage of bus bar no.5 is very low before connected PV and

finds out its optimal placement for connecting PV see in blue color line in a curve, after connected PV in bus bar no.5 the voltage level improving see in figure no.1 red line.

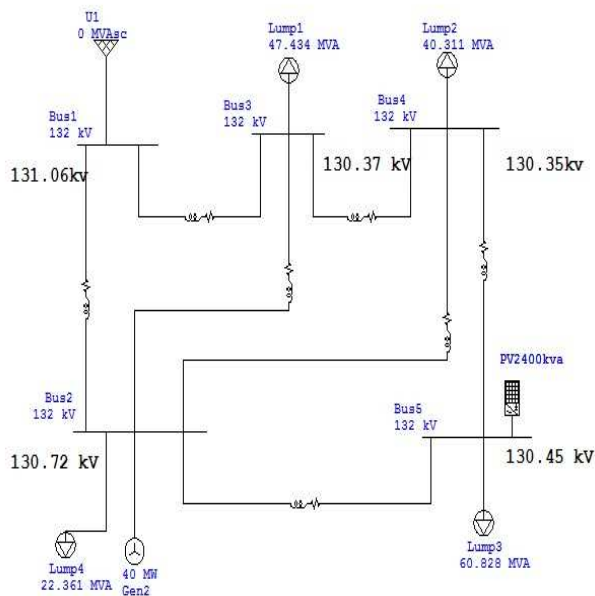


Fig.2 Simulation of IEEE5 Bus Bars before PV connected

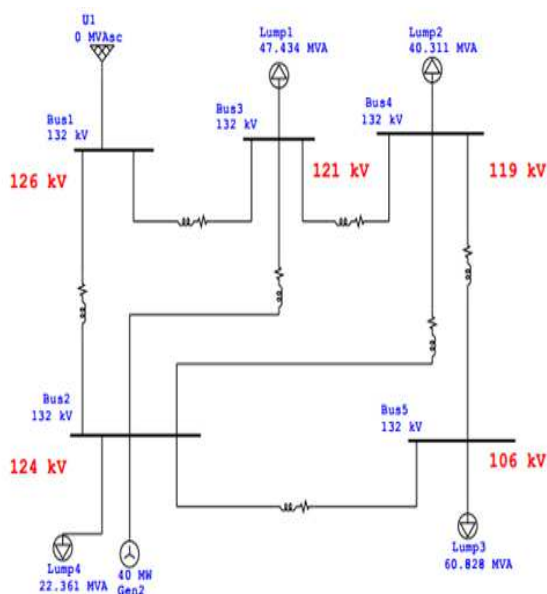


Fig.3 Simulation of IEEE5 Bus Bars after PV connected

Figures no.2 and no.3, simulation of IEEE5 Bus Bars, show the simulation of IEEE 5 bus bars and voltage level in every bus bar, before and after connected PV on Bus Bar no.5, the voltage level improving as mentioned in table no.1 before and after connecting PV.

5. CONCLUSION

This work concluded with placing photovoltaic (PV) into distribution systems (IEEE5BB) of Kirkuk city. using the Newton Raphson method with MATLAB code and E-Tap software flow analysis. This method has proven its effectiveness exclusively through simulations represented in theoretical models. Coupling Simulations In addition, results matching the couplings you made in MATLAB Code Connection were performed. The study concluded that the method is used to measure the power systems of the placement systems and the optimal size and optimum location of the photovoltaic energy systems in the distribution systems and their performance. Work to find the best place like (Table + Figure) no.1 bus bar 5; it is the optimal location for PV. Also, find out lower losses and overvoltage.

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