



## GRIDLAB-D™ SOFTWARE EFFICIENCY ANALYSIS USING THE NEWTON-RAPHSON METHOD FOR POWER FLOW ANALYSIS OF ELECTRICAL SYSTEMS COMPARED TO MATLAB®

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### ABSTRACT

The GridLAB-D™, which was launched in 2007, and consists of an open platform developed by the US Department of Energy at the Pacific Northwest National Laboratory. Firstly, this paper presents an introduction about the platform and the development of the program, followed by the presentation of the Newton-Raphson method applied to power flow. The method is part of the mathematical scope called numerical methods, which solve systems and equations in an algorithmic way, and indicates the desired precision as a stop method for the sequence of iterations performed by the method. This work was developed with the objective of analyzing the effectiveness of the GridLAB-D™ in the power flow analysis. This exam takes into account the interface, usability, execution time and accuracy of results offered by the program. The program successfully resolves the analysis of the proposed system in 10 seconds, while the same logic run in Matlab® has an execution time of 2 minutes. This time is considerably significant given the complex logic of the programs. In contrast to Matlab®, GridLAB-D™ is an open platform graphical program, while this first program is costly and does not allow modification by the user.

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### INTRODUCTION

The GridLAB-D™ software was developed by the US Department of Energy (DOE) at the Pacific Northwest National Laboratory (PNLL) in partnership with (GRIDLAB-D, 2018). According to the official website of the program, it is a simulator developed to assist various types of users, from electric system operators to students in the area, in the analysis of energy distribution systems. As the main differential, the GridLAB-D™ presents itself in an open platform, free of charge, allowing the user to change the platform and interact with various softwares available in the market.

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The program does not have advanced features in the sense of interface, its work environment is presented in Operating System on Disk (DOS). This characteristic is one of the main ones indicated as an accelerating factor in the analysis of the inserted data. Although it has no accessible layout, as shown in figure 1, the program is produced to work in high level language, with an environment similar to that programmable in the C language. It has several functions that can be implemented according to the user's wishes, allowing the analysis of distributed generation systems, whether or not integrated into control systems, in an accessible manner. The utility can be integrated with other platforms and other data analysis software, such as Excel or Matlab®, boosting its functions.

**Gauss-Seidel Method:** Due to different data types and various denominations referring to the bar, there is a difficulty

analyzing problems in the load flow scope. We highlight a difficulty to analyze algebraically problems of this scope, are used mathematical analysis techniques to do so. These systems are even adopted in systems of computational analysis. These methods follow an iterative process, which makes their approach time consuming, although effective (Stevenson, 1986). Gauss-Seidel is one of the methods used to perform this analysis. Initially, the bars and their characteristics (generation, load or reference) are analyzed, so that a system of equations can be assembled, analyzed and repeated until the results show a precision lower than a pre-set amount (Stevenson, 1986). According to Stevenson (1986), the Gauss-Seidel method requires a large number of iterations until this precision value is reached. There are acceleration methods of this process, but even with their implementation they do not guarantee a desirable agility, mainly computationally.

### Newton-Raphson Method

The Newton-Raphson method comes from the same necessity that culminated in the creation of the Gauss-Seidel. This feature comes from the expansion of the Taylor series to a multivariate function. In addition to the algebraic analysis of equations, partial derivatives for Jacobian solution are also applied. Compared with the Gauss-Seidel method, which has a significant increase in the number of iterations according to the number of bars, Newton-Raphson's method does not have this drawback. For this reason the GridLAB-D<sup>TM</sup> has a specific function that guarantees the execution of the Newton-Raphson method using loops similar to the C language, which allows this analysis in a small code.

## METHODS

All steps of the simulation were realized an Acer brand notebook, with Intel® Core™ i5-7200U 2.5 GHz processor with Turbo Boost up to 3.1 GHz, Intel® HD graphics and 8GB DDR4 memory. In this simulation we used the program in the GridLAB-D<sup>TM</sup> version 10.0.17134.81 and the Notepad, both in Windows 10. For comparison it is used the Matlab 2014, for analysis of the result of the execution time, in the same computer.

### The analyzed system has four bars, where

- Bar 1 is the slack bar, connected to bars 2 and 3 and with active and reactive power consumed of 0.50 and 0.31 pu, respectively;
- Bar 2 is a load bar, connected to bars 1 and 4 and with active and reactive power consumed of 1.70 and 1.05 pu, respectively;
- Bar 3 is a load bar, connected to bars 1 and 4 and with active and reactive power consumption of 2.00 and 1.24 pu, respectively; and
- Bar 4 is a generation bar, connected to bars 2 and 3 and with active and reactive power consumed of 0.80 and 1.02 pu respectively and active power generated of 3.18 pu.

The admittance matrix (Ybus) of the system is as follows:

Regarding both codes, its first implemented the notes environment. In the environment in question, the observed distribution network is treated as a system of nodes and links,



Source: Author.

Figure 1. Grid LAB-D<sup>TM</sup> user interface with the user

Table 1. Ybus matrix

Identification of bar	1	2	3	4
1	9- j44.84	-3.42 + j19.48	-5.17 + j25.85	0
2	-3.42 + j19.08	9 - j44.84	0	-5.17 + j25.85
3	-5.17 + j25.85	0	8.20 - j40.87	-3.02 + j15.11
4	0	-5.17 + j25.85	-3.02 + j15.11	8.20 - j40.87

Source: Author

Table 2. Results generated by the software

Line	Voltage (pu)	Active Power Generated (pu)	Reactive Power Generated (pu)
1	1.000∠0°	2.176	1.106
2	0.982∠-1.464°	0	0
3	0.9690∠-2.18°	0	0
4	1.020∠1.057°	3.180	1.886

Source: Author.

the nodes being the voltages and links, the currents. However, as in this simulation only the voltages that scan the system are analyzed, only nodes are used. Scans are repeated until system conversion. All power magnitudes, line length, line losses are defined in power flow objects, integrated into the main code. The integrated Newton-Raphson solver is used to ensure the agility of the program. In the code it is demanded that the response be presented in an independent “.html” file, as a factor of delay of the simulation time.

## RESULTS AND DISCUSSION

Both programs returns the following values of active and reactive power and voltage in the system through Newton-Raphson method: From this table, it is possible to notice that there is a balance between the system bus voltages, since these have a difference of less than 40% in their magnitude, with a negligible difference. However, the active and reactive losses correspond to 0.356 and 0.108 pu, respectively. Both programs returned the same value, given the possibility of pre-determining the adjusted accuracy. The difference observed for both programs is that while GridLAB-D™ returns a runtime of 10 seconds, Matlab® takes 2 minutes to perform this analysis. In GridLAB-D™ the code has been implemented with numerous functions and more than 100 lines, while Matlab® needed a more extensive logic to reach the goal.

## Conclusion

The method of analysis applied to the GridLAB-D™ simulates the analysis of load flow problems. The software simulates in an almost immediate time (10 seconds), with great precision. In advantage, the program has adjustable precision scale and very small execution time, even integrated with other programs, of average execution time, such as Excel. The same method applied to Matlab® took 2 minutes for compilation and output printing on external file. Considerably high time, given the low complexity of the code.

Taking this factor into account, GridLAB-D™ is more efficient. The main point favorable of GridLAB-D™ software is the fact that it is free, while Matlab® is a high-cost software. GridLAB-D™ is an open platform that can be modified by the user. The software does not have a user friendly interface because it is presented in DOS, but this environment is the main contributing factor for the program to run in a satisfactory time. Another key feature that counteracts the lack of interface is the maintenance of accelerated time when integrated with other software. There is no significant change, in addition to seconds, of the execution time between printing the file at prompt or external program. GridLAB-D™ still is a unknown software in Brazil, but its have a big pottencial. Its use can be applied to many areas in energy efficiency and injection of power originated in smart grid, fact that is rising in all world, due to diversification of energetic matrix and concatenation of many areas of electrical engineering in the production of energy.

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## REFERENCES

- GRIDLAB-D™. GridLAB-D: Welcome. 2018. Available in: <<https://www.gridlabd.org/>>. Access in: May 14, 2018.
- STEVENSON, Jr. WD (1986). Elementos de Análise de Sistemas de Potência. 2a Ed. São Paulo: McGraw-Hill.
- US DEPARTMENT OF ENERGY - DOE (2017). GridLAB-D™, version 10.0.17134.81. Open License BSD.

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