Science and Technology Publishing (SCI & TECH)
ISSN: 2632-1017
Vol. 7 Issue 2, February - 2023

Comparison Of Load Flow Analysis On IEEE 33 Bus System Based On Newton Raphson And Fast Decoupled Methods

Ukut, Uwem Isong[1]
Dept of Electrical and Electronic Engineering
University of Uyo, Uyo. Akwa Ibom State, Uyo, Nigeria

Okpura, Nseobong[2]
Dept of Electrical and Electronic Engineering
University of Uyo, Uyo. Akwa Ibom State, Uyo, Nigeria
nseobongokpura@uniuyo.edu.ng

Tim Umoette[3]
Department of Electrical and Electronic Engineering, Akwa Ibom State
University Mkpat Enin, Akwa Ibom State, Nigeria

***Abstract*— In this paper, the comparison of load flow analysis on IEEE 33 bus system based on Newton Raphson and Fast Decoupled methods. The flowchart of the Newton Raphson method of load flow analysis and that of the Fast Decoupled method were presented. The study was based on the case study dataset of the IEEE 33 bus system. MATLAM program was developed based on the Newton Raphson flowchart and the Fast Decoupled method flowchart and the load flow analysis simulation was also conducted using each of the two methods. The Newton Raphson simulations converged on the 5th iteration while the fast decoupled load flow computations converged on the 13th iteration. The simulation results on the bus voltage show that the values estimated by Fast Decoupled method is very much similar to that obtained with the Newton Raphson method with maximum absolute percentage error of 1.26 % which occurred on bus 17. Also, the phase angle values estimated by the Fast Decoupled method is very much similar to that obtained with the Newton Raphson method with maximum absolute percentage error of 4.41 % which occurred on bus 31. The results show that the percentage error is zero (0 %) in most of the buses and only 12 buses have none zero percentage error in the bus voltages and phase angles.**

Keywords*— *Newton Raphson Method, Load Flow Analysis, IEEE 33 Bus System, Bus Voltage, Phase Angle, Fast Decoupled Method

1.0 Introduction

Nowadays, technological advancements and increasing applications of such technologies have made humans to increasingly rely on electric power supply to pursue and realise their daily life ambitions [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]. Advancements in electronic and wireless communication technologies, as well as Internet and Internet of Thins have led to the development of various smart systems that find applications in every aspect of human endeavour [17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32]. Today, cashless policy, ELearning solutions, e-government, mobile devices and web-based apps, smart attendance system, e-voting technologies and many others have emerged and are driving the present day policies across the globe [33,34,35,36,37,38,39,40,4,42,43,44,5]. Notably, researchers have shown that dependence on Internet and social media in on the increase [46,47,48,49]. Also electric power and Internet driven technologies continue to shape the way we relate with other people and with our self. In all these electrical and electronic technology driven solutions, the bedrock is electric power supply. As such, the major dividing line between the developed and the developing countries is their ability to generate sufficient electric power and the extent they can utilise the generated electricity to innovate other technological solutions that address different aspects of the societal problems [50,51,52,53].

Particularly, planning and designing effective large scale power system network that can support the national power demand is a very difficult task. Many factors comes into play, the ratio of generated power to the load demand which in in the case of Nigeria is very low [54,55,56]. Also, the available power system infrastructure and their capacities, the load demand growth pattern among others. Equally, in the present days, power systems networks are expected to accommodate distributed power generation [57,58,59]. In this case, different brands of power generating systems that may include wind, solar, biomass and other renewable energy sources may be included in the distributed power generation system. In all these situations, load flow analysis can be used by the power system experts to analyse the power network so as to determine the voltage profile and the active and reactive power flows in the network [60,61,62,63]. The analysis can be conducted for diverse power system configurations so as to plan ahead of probable issues that may arise in the power network. In view of the importance of power flow analysis, this paper presents comparison of load flow analysis on IEEE 33 bus system based on Newton Raphson and Fast Decoupled methods [64,65,66,67]. The essence of the study is to compare the two methods and determine their effectiveness in load flow analysis and hence recommend the best approach for conducting load flow analysis in power system.

2.0 Methodology

2.1 Newton Raphson Load Flow Method

Generally Newton Raphson (NR) iteration method is one of the best method for solving non-linear load flow equations because it affords faster convergence speed when compared with the other load flow analysis methods. There are several published studies on the application of NR method in load flow analysis and a sample flowchart of Newton Raphson (NR) load flow analysis as used in this paper is given in Figure 1.

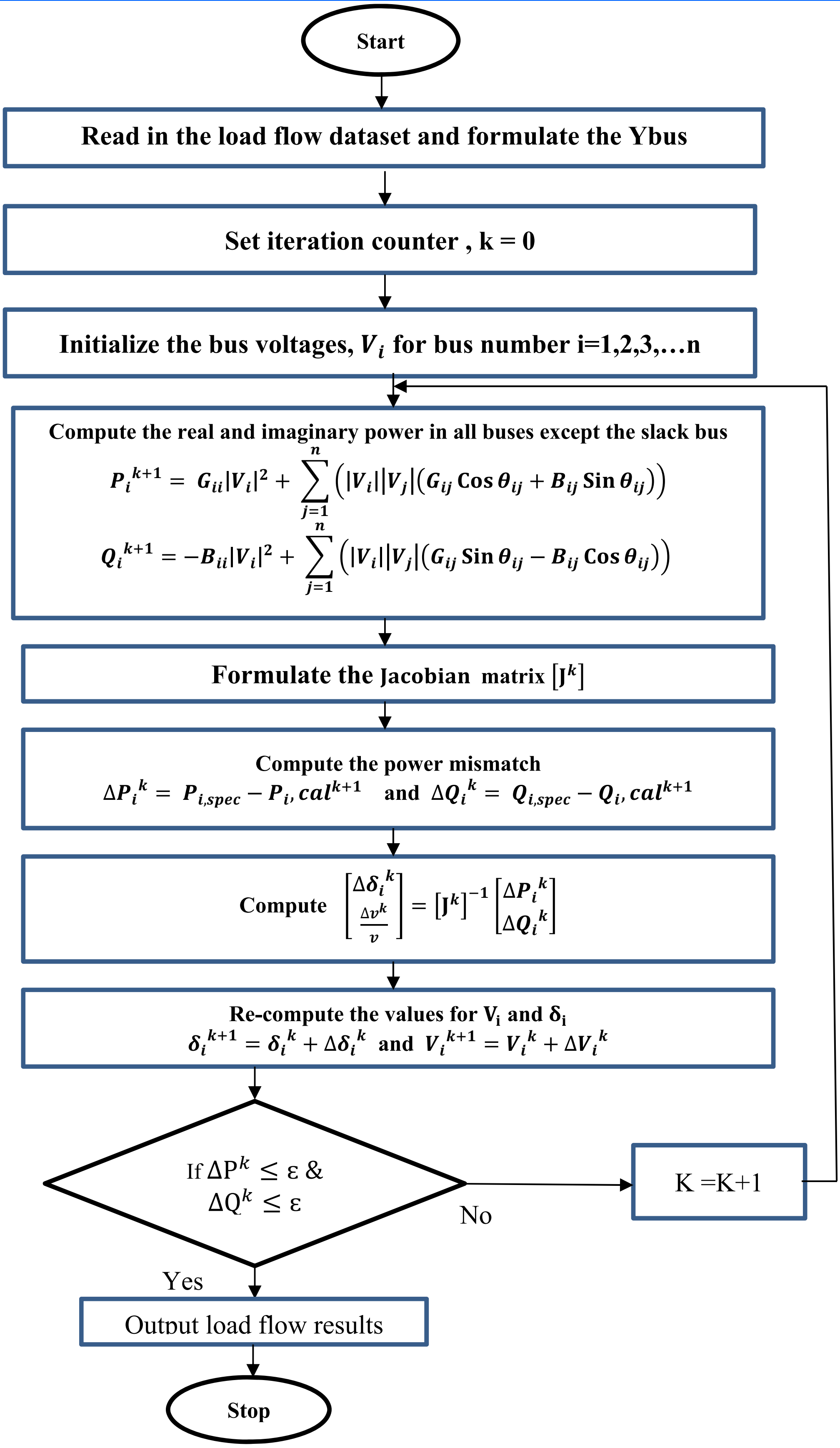

Figure 1 The flowchart of Newton Raphson (NR) load flow analysis method

2.2 Fast Decoupled Load Flow Method

The Fast Decoupled load flow (FDLF) method is based on the classical Newton-Raphson load flow method. The FDLF method makes some assumptions that enables it to simplify the Newton Raphson method and hence tends to offer faster convergence than the classical Newton Raphson method. In view of the assumptions made in the FDLF, the Jacobian matrix is reduced to about half as two components of the Jacobean matrix, namely J2 and J3 are ignored or assumed to be zero.

However, the value of the ratio of resistance –to-reactance or instance of low voltage at some buses do affect the convergence performance of FDLF method. Again, there are several published studies on the application of FDLF method in load flow analysis and a sample flowchart of Fast Decoupled load flow analysis as used in this paper is given in Figure 2.

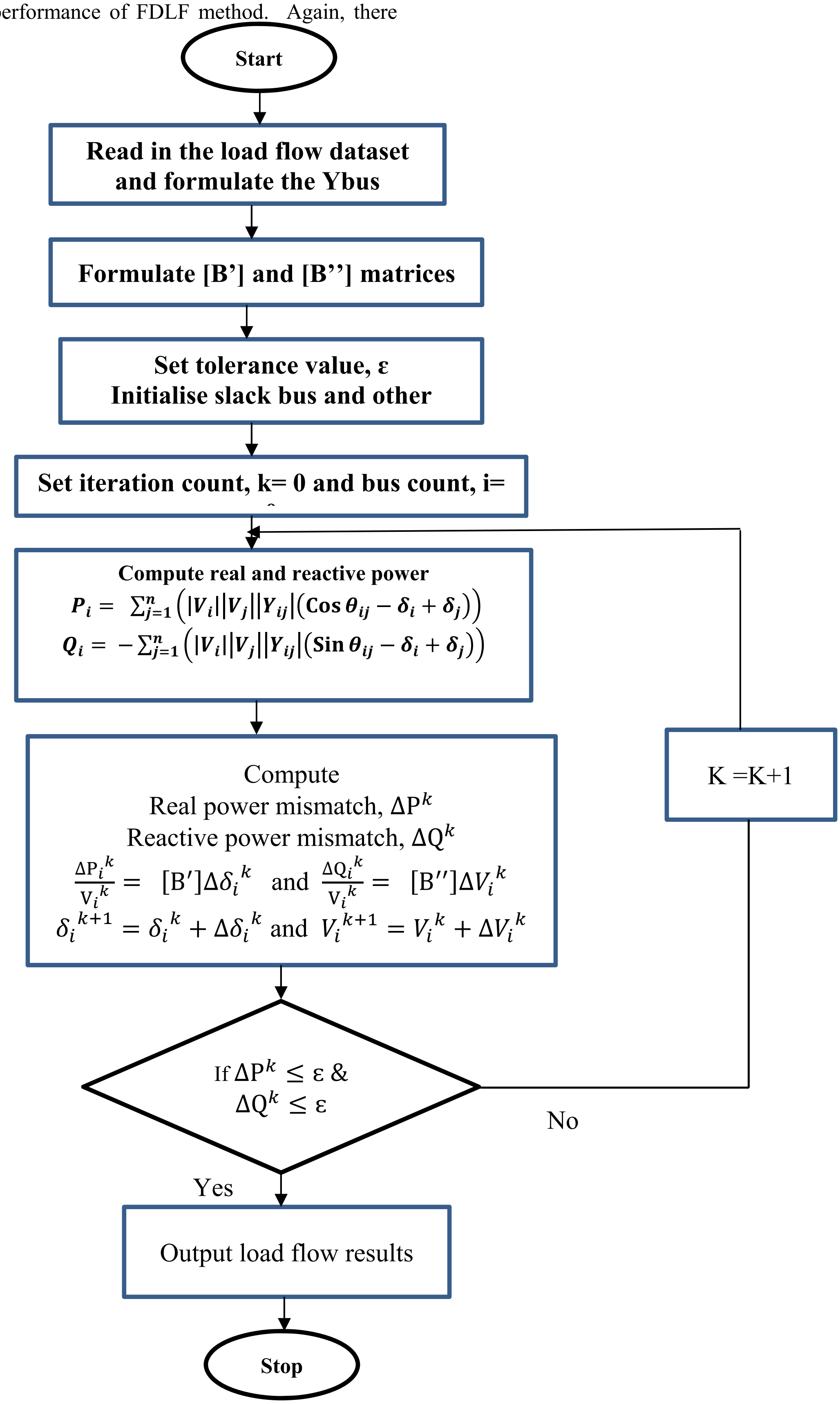

Figure 2 The flowchart of Fast Decoupled load flow method

2.3 Simulation and the dataset for the case study IEEE 33 bus system

The study is based on the case study dataset of the IEEE 33 bus system. The line data for the case study IEEE 33 bus system is shown in Table 1 while Table 2 shows the bus data for the case study IEEE 33 bus system.

Table 1 The line data for the case study IEEE 33 bus system

Bus Number	Sending Bus Number	Receiving Bus Number	Line Resistance	Line Reactance
1	1	2	0.0922	0.047
2	2	3	0.493	0.2511
3	3	4	0.366	0.1864
4	4	5	0.3811	0.1941
4	5	6	0.819	0.707
6	6	7	0.1872	0.6188
7	7	8	0.7114	0.2351
8	8	9	1.03	0.74
9	9	10	1.044	0.74
10	10	11	0.1966	0.065
11	11	12	0.3744	0.1238
12	12	13	1.468	1.155
13	13	14	0.5416	0.7129
14	14	15	0.591	0.526
15	15	16	0.7463	0.545
16	16	17	1.289	1.721
17	17	18	0.732	0.574
18	2	19	0.164	0.1565
19	19	20	1.5042	1.3554
20	20	21	0.4095	0.4784
21	21	22	0.7089	0.9373
22	3	23	0.4512	0.3083
23	23	24	0.898	0.7091
24	24	25	0.896	0.7011
25	6	26	0.203	0.1034
26	26	27	0.2842	0.1447
27	27	28	1.059	0.9337
28	28	29	0.8042	0.7006
29	29	30	0.5075	0.2585
30	30	31	0.9744	0.963
31	31	32	0.3105	0.3619
32	32	33	0.341	0.5302

Table 2 The bus data for the case study IEEE 33 bus system

Bus Number	LOAD: Active Power (KW)	LOAD : Reactive Power (KVAR)	Q Injected	Bus Number	LOAD: Active Power (KW)	LOAD : Reactive Power (KVAR)	Q Injected
1	0	0	0	17	60	20	0
2	100	60	0	18	90	40	0
3	90	40	0	19	90	40	0
4	120	80	0	20	90	40	0
5	60	30	0	21	90	40	0
6	60	20	0	22	90	40	0
7	200	100	0	23	90	50	0
8	200	100	0	24	420	200	0
9	60	20	0	25	420	200	0
10	60	20	0	26	60	25	0
11	45	30	0	27	60	25	0
12	60	35	0	28	60	20	0
13	60	35	0	29	120	70	0
14	120	80	0	30	200	600	0
15	60	10	0	31	150	70	0
16	60	20	0	32	210	100	0
17	60	20	0	33	60	40	0

3. Results and discussion

MATLAM program was developed based on the Newton Raphson flowchart in Figure 1 and the Fast Decoupled method flowchart in Figure 2 and the load flow analysis simulation was also conducted using each of the two methods and the results are presented in tables and graphs. The Newton Raphson simulations converged on the 5^{th} iteration while the fast decoupled load flow computations converged on the 13th iteration. The results on bus voltage magnitudes obtained from the Newton Raphson and the fast decoupled methods are shown in Table 3 while the results on the phase angles obtained from the Newton Raphson and the fast decoupled methods are shown in Table 4. The results on the percentage error (%) of the Fast Decoupled estimated bus voltage magnitude relative to the value computed with the Newton Raphson method as the base case are shown in Table 3 and Figure 4. Similarly, the results on the percentage error (%) of the Fast Decoupled estimated phase angles relative to the value computed with the Newton Raphson method as the base case are shown in Table 4 and Figure 5.

The results of the bus voltage show that the estimated bus voltage by the Fast Decoupled method is very much similar to that obtained with the Newton Raphson method with maximum absolute percentage error of 1.26 % which occurred on bus 17. Also, the phase angle values estimated by the Fast Decoupled method is very much similar to that obtained with the Newton Raphson method with maximum absolute percentage error of 4.41 % which occurred on bus 31. The results show that the percentage error is zero (0 %) in most of the buses and only 12 buses have none zero percentage error in the bus voltages and phase angles.

Table 3 The results of the bus voltage magnitudes obtained from the Newton Raphson and the fast decoupled methods

Bus Number	Bus Voltage (p.u.) obtained with Newton Raphson Load Flow Method	Bus Voltage (p.u.) obtained with Fast Decoupled Load Flow Method	Error (p.u.)	Percentage Error (%)
1	1	1	0	0
2	0.9862	0.9862	0	0
3	0.927	0.927	0	0
4	0.8924	0.8924	0	0
5	0.8607	0.8607	0	0
6	0.7693	0.7693	0	0
7	0.7277	0.7277	0	0
8	0.7236	0.7236	0	0
9	0.7036	0.7036	0	0
10	0.6954	0.6954	0	0
11	0.6981	0.6981	0	0
12	0.7032	0.7072	-0.004	-0.56883
13	0.7077	0.7037	0.004	0.565211
14	0.7053	0.7033	0.002	0.283567
15	0.7085	0.7095	-0.001	-0.14114
16	0.7135	0.7175	-0.004	-0.56062
17	0.715	0.724	-0.009	-1.25874
18	0.717	0.723	-0.006	-0.83682
19	0.9821	0.9791	0.003	0.305468
20	0.9543	0.9583	-0.004	-0.41916
21	0.9486	0.9486	0	0
22	0.9432	0.9452	-0.002	-0.21204
23	0.9198	0.9188	0.001	0.108719
24	0.9094	0.9094	0	0
25	0.9042	0.9042	0	0
26	0.7635	0.7635	0	0
27	0.7568	0.7568	0	0
28	0.7226	0.7226	0	0
29	0.7025	0.7025	0	0
30	0.6971	0.6971	0	0
31	0.6815	0.6805	0.001	0.146735
32	0.6776	0.6776	0	0
33	0.6746	0.6746	0	0

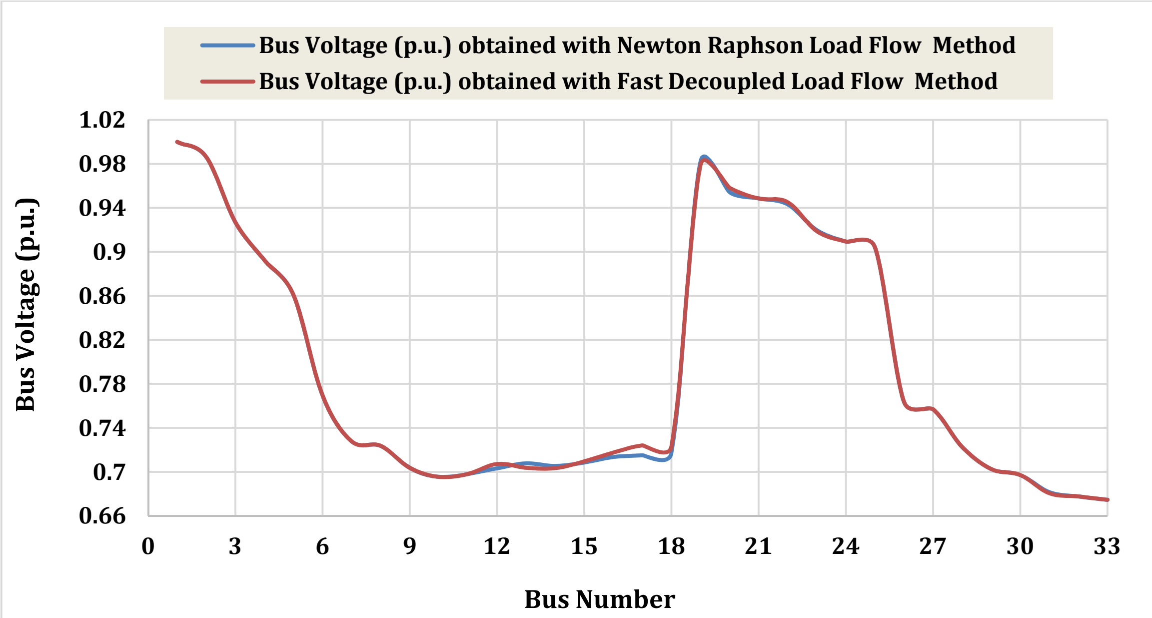

Figure 3 The flowchart of Fast Decoupled load flow method

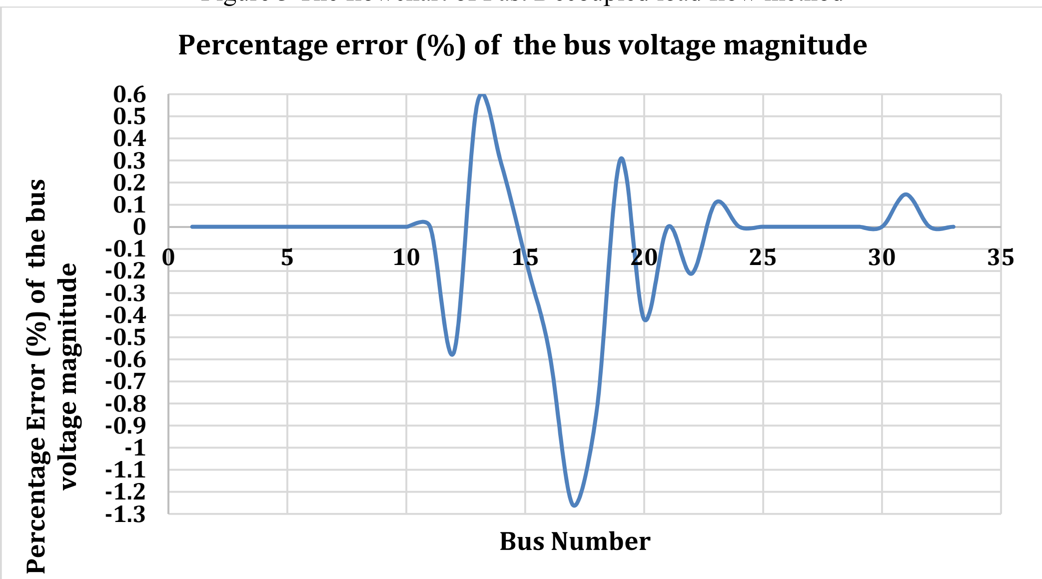

Figure 4 The results on the percentage error (%) of the Fast Decoupled estimated bus voltage magnitude relative to the value computed with the Newton Raphson method as the base case

Table 4 The results of the phase angles obtained from the Newton Raphson and the fast decoupled methods

Bus Number	Phase angle in radians obtained with Newton Raphson Load Flow Method	Phase angle in radians obtained with Fast Decoupled Load Flow Method	Error (p.u.0	Percentage error (%) of the Phase angle
1	0	0	0	0
2	0.0116	0.0116	0	0
3	0.0743	0.0743	0	0
4	0.1218	0.1219	-1E-04	-0.0821
5	0.1739	0.174	-1E-04	-0.0575
6	0.2954	0.299	-0.0036	-1.21869
7	0.3218	0.3218	0	0
8	0.3904	0.3904	0	0
9	0.4948	0.4948	0	0
10	0.5951	0.5951	0	0
11	0.6094	0.6094	0	0
12	0.633	0.6329	1E-04	0.015798
13	0.7334	0.73	0.0034	0.463594
14	0.7737	0.7732	0.0005	0.064625
15	0.8019	0.8019	0	0
16	0.8253	0.8253	0	0
17	0.8631	0.8631	0	0
18	0.8706	0.8721	-0.0015	-0.17229
19	0.0116	0.0116	0	0
20	0.0124	0.0124	0	0
21	0.0118	0.0118	0	0
22	0.011	0.011	0	0
23	0.0769	0.0769	0	0
24	0.08	0.08	0	0
25	0.0814	0.0814	0	0
26	0.3074	0.3074	0	0
27	0.3226	0.3223	0.0003	0.092994
28	0.3739	0.3739	0	0
29	0.409	0.4088	0.0002	0.0489
30	0.4272	0.4272	0	0
31	0.4554	0.4755	-0.0201	-4.4137
32	0.4616	0.4747	-0.0131	-2.83795
33	0.4653	0.4781	-0.0128	-2.75091

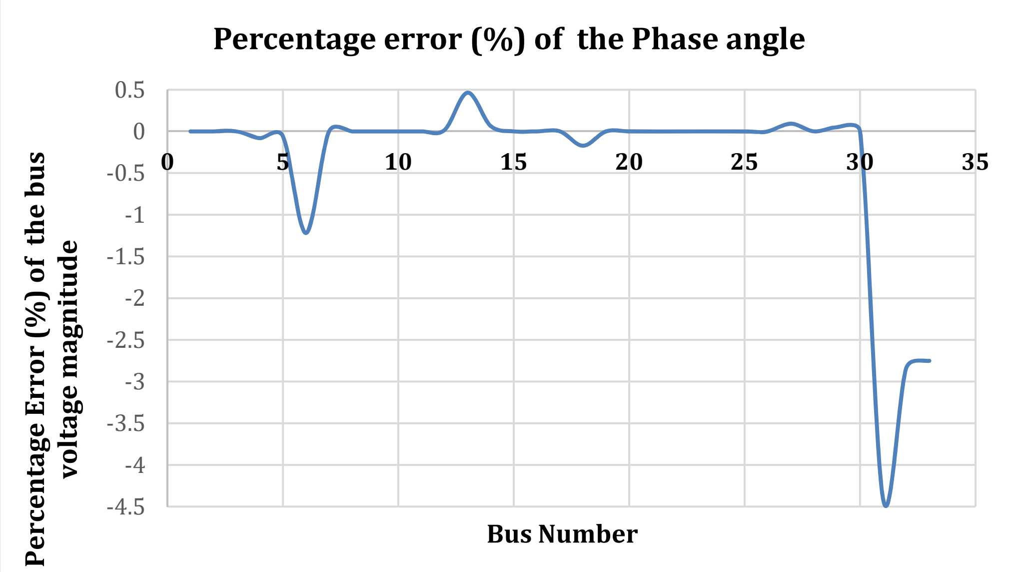

Figure 5 The results on the percentage error (%) of the Fast Decoupled estimated phase angles relative to the value computed with the Newton Raphson method as the base case

4. Conclusion

The load flow analysis capability of Fast Decoupled method is evaluated relative to that of the Newton Raphson method. The comparison is done with respect to the bus voltages and phase angles estimated using the Fast Decoupled method and the Newton Raphson method. The percentage error is estimated and the maximum absolute percentage error is obtained for the two parameters. The percentage error is zero (0 %) in most of the buses and only 12 buses have none zero percentage error in the bus voltages and phase angles.

References

1. Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced research*, *3*(1), 45-47.
2. Wu, J., Guo, S., Huang, H., Liu, W., & Xiang, Y. (2018). Information and communications technologies for sustainable development goals: state-of-the-art, needs and perspectives. *IEEE Communications Surveys & Tutorials*, *20*(3), 2389-2406.
3. Luo, X., Wang, J., Dooner, M., & Clarke, J. (2015). Overview of current development in electrical energy storage technologies and the application potential in power system operation. *Applied energy*, *137*, 511-536.
4. Shah, M. M., Sirojuzilam, S., & Maas, L. T. (2020). The Development Impact of PT. Medco E & P Malaka on Economic Aspects in East Aceh Regency. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, *3*(1), 276-286.
5. Zion, Idongesit, Simeon Ozuomba, and Philip Asuquo. (2020) "An Overview of Neural Network Architectures for Healthcare." *2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS)*. IEEE, 2020
6. Akorede, M. F., Ibrahim, O., Amuda, S. A., Otuoze, A. O., & Olufeagba, B. J. (2017). Current status and outlook of renewable energy development in Nigeria. *Nigerian Journal of Technology*, *36*(1), 196-212.
7. Chikezie, Aneke, Ezenkwu Chinedu Pascal, and Ozuomba Simeon. (2014). "Design and Implementation Of A Microcontroller-Based Keycard." *International Journal of Computational Engineering Research (IJCER) Vol, 04 Issue, 5 May – 2014*
8. Simeon, Ozuomba. (2018) "Sliding Mode Control Synthesis For Autonomous Underwater Vehicles" *Science and Technology Publishing (SCI & TECH*
9. Wojuola, R. N., & Alant, B. P. (2019). Sustainable development and energy education in Nigeria. *Renewable energy*, *139*, 1366-1374.
10. Graham, M., Hjorth, I., & Lehdonvirta, V. (2017). Digital labour and development: impacts of global digital labour platforms and the gig economy on worker livelihoods. *Transfer: European review of labour and research*, *23*(2), 135-162.
11. Ozuomba, Simeon, and Etinamabasiyaka Edet Ekott. (2020). "Design And Implementation Of Microcontroller And Internet Of Things-Based Device Circuit And Programs For Revenue Collection From Commercial Tricycle Operators." *Science and Technology Publishing* (SCI & TECH) Vol. 4 Issue 8, August – 2020
12. Otumdi, Ogbonna Chima, Kalu Constance, and Ozuomba Simeon (2018). "Design of the Microcontroller Based Fish Dryer." *Journal of Multidisciplinary Engineering Science Studies (JMESS) Vol. 4 Issue 11, November - 201*
13. Ozuomba, Simeon, Ekaette Ifiok Archibong, and Etinamabasiyaka Edet Ekott (2020). Development Of Microcontroller-Based Tricycle Tracking Using Gps And Gsm Modules. *Journal of Multidisciplinary Engineering Science and Technology (JMEST) Vol. 7 Issue 1, January - 2020*
14. Maduka, N. C., Simeon Ozuomba, and E. E. Ekott. . (2020) "Internet of Things-Based Revenue Collection System for Tricycle Vehicle Operators." *2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS)*. IEEE, 2020.
15. Stephanidis, C., Salvendy, G., Antona, M., Chen, J. Y., Dong, J., Duffy, V. G., ... & Zhou, J. (2019). Seven HCI grand challenges. *International Journal of Human–Computer Interaction*, *35*(14), 1229-1269.

16. Thompson, E., Simeon, O., & Olusakin, A. (2020). A survey of electronic heartbeat electronics body temperature and blood pressure monitoring system. Journal of Multidisciplinary Engineering Science Studies (JMESS) Vol. 6 Issue 8, August – 2020

17. Ozuomba Simeon, Chukwedebe G. A. , Opara F. K., Ndinechi M. (2013) Preliminary Context Analysis Of Community Informatics Social Network Web Application. *Nigerian Journal of Technology (NIJOTECH)* Vol. 32. No. 2. July 2013, pp. 266-272

18. Pedrycz, W., & Chen, S. M. (Eds.). (2011). *Granular computing and intelligent systems: design with information granules of higher order and higher type* (Vol. 13). Springer Science & Business Media.

19. Magnisalis, I., Demetriadis, S., & Karakostas, A. (2011). Adaptive and intelligent systems for collaborative learning support: A review of the field. *IEEE transactions on Learning Technologies*, *4*(1), 5-20.

20. Bednar, P. M., & Welch, C. (2020). Socio-technical perspectives on smart working: Creating meaningful and sustainable systems. *Information Systems Frontiers*, *22*(2), 281-298.

21. Finn, A., & Scheding, S. (2010). Developments and challenges for autonomous unmanned vehicles. *Intelligent Systems Reference Library*, *3*, 128-154.

22. Dudley, J. J., & Kristensson, P. O. (2018). A review of user interface design for interactive machine learning. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, *8*(2), 1-37Ezenkwu C. P , Ozuomba Simeon, Kalu C. (2013) Community informatics social network for facilitated community policing: A case study of Nigeria . *Software Engineering* 2013; Vol.1(No.3): PP 22-30 . Published online November 20, 2013

23. Ezenkwu C. P , Ozuomba Simeon, Amaefule O. C. (2013) The Pure-Emic User Interface Design Methodology for an Online Community Policing Hub. *Computer Engineering and Intelligent Systems* Vol.4, No.11, 2013. ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

24. Nicholas Aigbobhiose Esene, Simeon Ozuomba, obinwa Christian Amaefule (2013) Strategies for Improving Software Development and Acquisition Practices in Developing Countries. International Journal of Computer (ISSN 2307-4531) Vol. 8 No 1 (2013)

25. Ozuomba, Simeon. (2013). Triple-win user innovation network and facilitated all-inclusive collective enterprise (TWUINFAICE): A postdoctoral research agenda for turning the youth bulge in Africa into blessing. *Science Innovation1*(3), 18-33.

26. Chinedu Pascal Ezenkwu , Simeon Ozuomba , Constance Kalu (2015) , *Application of k-Means Algorithm for efficient Customer Segmentation: A strategy for targeted customer services. (IJARAI) International Journal of Advanced Research in Artificial Intelligence, Vol. 4, No.10, 2015*

27. Gordon, O., Ozuomba, Simeon. & Ogbajie, I. (2015). Development of educate: a social network web application for e-learning in the tertiary institution. *European Journal of Basic and Applied Sciences, 2 (4)*, 33-54.

28. Ezeonwumelu, P., Ozuomba, Simeon. & Kalu, C. (2015). Development of swim lane workflow process map for enterprise workflow management information system (WFMIS): a case study of comsystem computer and telecommunication ltd (CCTL) EKET. *European Journal of Engineering and Technology, 3 (9)*, 1-13.

29. Ozuomba, Simeon, Kalu, C., & Anthony, U. M. (2015). Map Mashup Application And Facilitated Volunteered Web-Based Information System For Business Directory In Akwa Ibom State. *European Journal of Engineering and Technology Vol*, *3*(9).

30. Akpasam Joseph Ekanem, Simeon Ozuomba, Afolayan J. Jimoh (2017) Development of Students Result Management System: A case study of University of Uyo. *Mathematical and Software Engineering*, Vol. 3, No. 1 (2017), 26-42.

31. Inyang, Imeobong Frank, Simeon Ozuomba, and Chinedu Pascal Ezenkwu.(2017) "Comparative analysis of Mechanisms for Categorization and Moderation of User Generated Text Contents on a Social E-Governance Forum." *Mathematical and Software Engineering* 3.1 (2017): 78-86.

32. Mathew-Emmanuel, Eze Chinenye, Simeon Ozuomba, and Constance Kalu. (2017) "Preliminary Context Analysis of Social Network Web Application for Combating HIV/AIDS Stigmatization." *Mathematical and Software Engineering* 3.1 (2017): 99-107

33. Stephen, B. U., Ozuomba, Simeon, & Eyibo, I. E. (2018). Development of Reward Mechanism for Proxy Marketers Engaged in E-Commerce Platforms. *European Journal of Engineering and Technology Research, 3(10), 45-52.*

34. Eyibo, I. E., Ozuomba, Simeon, & Stephen, B. U. A. (2018). DEVELOPMENT OF TRUST MODEL FOR PROXY MARKETERS ENGAGED IN E-COMMERCE PLATFORMS. *European Journal of Engineering and Technology Vol, 6(4).*

35. Ozuomba, Simeon, Constant Kalu, and Akpasam Joseph. (2018). Development of Facilitated Participatory Spatial Information System for Selected Urban Management Services. *Review of Computer Engineering Research, 5(2), 31-48.*

36. Kalu, Constance, Simeon Ozuomba, and Sylvester Isreal Umana. (2018). Development of Mechanism for Handling Conflicts and Constraints in University Timetable Management System. *Communications on Applied Electronics (CAE) 7(24).*

37. Ekanem, Mark Sunday, and Simeon Ozuomba. (2018). ONTOLOGY DEVELOPMENT FOR PEDAGOGIC CONTENT INFORMATICS. *European Journal of Engineering and Technology Vol, 6(4).*

38. Bassey, M. U., Ozuomba, Simeon, & Stephen, B. U. A. (2019). DEVELOPMENT OF A FACILITATED CROWD-DRIVEN ONLINE PROFIT-MAKING SYSTEM. *European Journal of Engineering and Technology Vol, 7(5).*

39. Ibanga, Jude, and Ozuomba Simeon, Obot, Akaniyene. B. (2020) "Development of Web-Based Learning Object Management System." Development 7, no. 3 (2020). *Journal of Multidisciplinary Engineering Science and Technology (JMEST) Vol. 7 Issue 3, March - 2020*

40. Simeon Ozuomba , Gloria A. Chukwudebe , Felix K. Opara and Michael Ndinechi (2014)Chapter 8: Social

Networking Technology: A Frontier Of Communication For Development In The Developing Countries Of Africa . *In Green Technology Applications for Enterprise and Academic Innovation (Chapter 8).* IGI Global, Hershey, PA 17033-1240, USA

41. Ezenkwu, Chinedu Pascal, Simeon Ozuomba, and Constance Kalu. (2013). "Strategies for improving community policing in Nigeria through Community Informatics Social Network." *2013 IEEE International Conference on Emerging & Sustainable Technologies for Power & ICT in a Developing Society (NIGERCON).* IEEE, 2013.

42. Nicholas A. E., Simeon O., Constance K. (2013) Community informatics social e-learning network: a case study of Nigeria *Software Engineering 2013; 1(3): 13-21*

43. Ozuomba Simeon and Chukwudebe G. A.(2011) ; *Strategies For Improving Software Development And Acquisition Practices in Developing Countries*. The paper was presented in the 1ST International Conference of IEEE NIGERCON 2010, 17 th – 19th 2010. It was then published in the Proceeding of the 1ST INTERNATIONAL Confrence of IEEE NIGERCON, Vol 1 No. 1, Page 38 -47

44. Anietie Bassey, Simeon Ozuomba & Kufre Udofia (2015). An Effective Adaptive Media Play-out Algorithm For Real-time Video Streaming Over Packet Networks. European. *Journal of Basic and Applied Sciences Vol, 2(4).*

45. Kalu, C., Ozuomba, Simeon. & Udofia, K. (2015). Web-based map mashup application for participatory wireless network signal strength mapping and customer support services. *European Journal of Engineering and Technology, 3 (8)*, 30-43.

46. Griffiths, M. D., Kuss, D. J., & Demetrovics, Z. (2014). Social networking addiction: An overview of preliminary findings. *Behavioral addictions*, 119-141.

47. Salehan, M., & Negahban, A. (2013). Social networking on smartphones: When mobile phones become addictive. *Computers in human behavior*, *29*(6), 2632-2639.

48. Kuss, D. J., & Griffiths, M. D. (2017). Social networking sites and addiction: Ten lessons learned. *International journal of environmental research and public health*, *14*(3), 311.

49. Livingstone, S., & Brake, D. R. (2010). On the rapid rise of social networking sites: New findings and policy implications. *Children & society*, *24*(1), 75-83.

50. Kaygusuz, K. (2012). Energy for sustainable development: A case of developing countries. *Renewable and Sustainable Energy Reviews*, *16*(2), 1116-1126.

51. O'Rourke, R. (2010). China naval modernization: Implications for US navy capabilities: Background and issues for congress.

52. Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, *2*(1), 1-17.

53. Graafland, J. H. (2018). New technologies and 21st century children: Recent trends and outcomes.

54. Sambo, A. S., Garba, B., Zarma, I. H., & Gaji, M. M. (2010). Electricity generation and the present challenges in the Nigerian power sector.

55. Emodi, N. V., Emodi, C. C., Murthy, G. P., & Emodi, A. S. A. (2017). Energy policy for low carbon development in Nigeria: A LEAP model application. *Renewable and Sustainable Energy Reviews*, *68*, 247-261.

56. Gyamfi, S., Modjinou, M., & Djordjevic, S. (2015). Improving electricity supply security in Ghana—The potential of renewable energy. *Renewable and sustainable energy reviews*, *43*, 1035-1045.

57. Balaguer, I. J., Lei, Q., Yang, S., Supatti, U., & Peng, F. Z. (2010). Control for grid-connected and intentional islanding operations of distributed power generation. *IEEE transactions on industrial electronics*, *58*(1), 147-157.

58. Willis, H. L. (Ed.). (2018). *Distributed power generation: planning and evaluation*. Crc Press.

59. Odetayo, B., MacCormack, J., Rosehart, W. D., & Zareipour, H. (2017). A chance constrained programming approach to integrated planning of distributed power generation and natural gas network. *Electric Power Systems Research*, *151*, 197-207.

60. Karimi, M., Shahriari, A., Aghamohammadi, M. R., Marzooghi, H., & Terzija, V. (2019). Application of Newton-based load flow methods for determining steady-state condition of well and ill-conditioned power systems: A review. *International Journal of Electrical Power & Energy Systems*, *113*, 298-309.

61. Aly, M. M., Abdel-Akher, M., Ziadi, Z., & Senjyu, T. (2014). Assessment of reactive power contribution of photovoltaic energy systems on voltage profile and stability of distribution systems. *International Journal of Electrical Power & Energy Systems*, *61*, 665-672.

62. Cuffe, P., Smith, P., & Keane, A. (2013). Capability chart for distributed reactive power resources. *IEEE Transactions on Power Systems*, *29*(1), 15-22.

63. Stanelyte, D., & Radziukynas, V. (2019). Review of voltage and reactive power control algorithms in electrical distribution networks. *Energies*, *13*(1), 58.

64. Afolabi, O. A., Ali, W. H., Cofie, P., Fuller, J., Obiomon, P., & Kolawole, E. S. (2015). Analysis of the load flow problem in power system planning studies. *Energy and Power Engineering*, *7*(10), 509.

65. Vijayvargia, A., Jain, S., Meena, S., Gupta, V., & Lalwani, M. (2016). Comparison between different load flow methodologies by analyzing various bus systems. *Int. J. Electr. Eng*, *9*(2), 127-138.

66. Janković, S., & Ivanović, B. (2015). Application of combined Newton–Raphson method to large load flow models. *Electric Power Systems Research*, *127*, 134-140.

67. Tortelli, O. L., Lourenco, E. M., Garcia, A. V., & Pal, B. C. (2014). Fast decoupled power flow to emerging distribution systems via complex pu normalization. *IEEE Transactions on Power Systems*, *30*(3), 1351-1358.