International Journal Of Artificial Intelegence Research
Vol 6, No 1, June 2022
ISSN: 2579-7298

Digital Simulation of Short Circuit Current Calculation Using Graphical User Interface for Learning Media Electric Power System Analysis

Rahmaniar[a,1], Agus Junaidi[b,2], Adi Sastra P Tarigana[a,3], Abdul Hakim Butar Butar[b,4]

[a]*Dept. of Electrical Engineering, Faculty of Science and Technology, Pembangunan Panca Budi University*
[b]*Dept. of Electrical Engineering, Faculty of Engineering, Negeri Medan University*
[1]*rahmaniar@dosen.pancabudi.ac.id*, [2]*agusjunaidi@unimed.ac.id*, [3]*adisastra@dosen.pancabudi.ac.id* ,
[4]*abdulhakimbutar@unimed.ac.id*
* *corresponding author*

ARTICLE INFO

Article history:
Received 19 March 2022
Revised 23 May 2022
Accepted 26 June 2022

Keywords:
Short Circuit
Electrical Power System
Digital Simulation
GUI
Learning Media

ABSTRACT

The research examines the design of a simulation program for short circuit calculations. A short circuit is an abnormal event called a disturbance in the electric power system. The classification of short circuit consists of three-phase fault, single-phase fault to ground, two-phase fault and two-phase fault to ground. Calculation of short circuit faults in electric power systems is very important for the study of reliability and safety of power systems. The method used in the design of the Graphical User Interface (GUI) based simulation program is the experimental method, which is to identify the magnitude of the short circuit current value based on the theorem of Fortescue's theorem related to symmetrical components. Furthermore, a GUI program script is built for short circuit calculations. The GUI success test was carried out by comparing the results of the short circuit analysis with the short circuit calculation program using Matlab and validation by experts. From the results of testing and validation by experts, it can be seen that the program built can complete the calculation of short circuit faults validly. The GUI SCC program can be applied to electric power system analysis learning, with a media validity level of 0.85, which is good for use in learning. In addition, this study also built a simulation for the calculation of class intervals and the practicality of the media using the Simulink Matlab media, the results of the program design were declared by experts to be valid with an average score of 0.8625.

I. Introduction

Utilization of technology as a learning aid is a powerful part of changing the learning paradigm and optimizing the learning targets to be achieved [1]–[4]. College graduates with creative skills and critical thinking are needed in the era of technological disruption, becoming an important concern for learning management, including the field of electrical engineering in higher education. The era of disruption has an impact on the emergence of new jobs with the need for competence in higher-order thinking skills and skills in utilizing technology, especially information technology and computers, becoming the need for new jobs in the future [5], [6]. Efforts to optimize the quality of human resources are carried out with recommendations on aspects of human resources and science and technology. The learning process focuses on aspects of access, quality and efficiency of learning, and has 4C competencies (Communication, Collaborative, Critical Thinking, and Creativity) [7].

Learning in the field of electrical engineering in the electrical engineering study program is found in 23 universities that have Electrical Engineering Study Programs in North Sumatra (from initial observations) at this time, it is necessary to optimize the cooperation of consortiums in the field of electric power system learning which allows strong social relations for students between study programs. electrical engineering so that the even distribution of graduate competencies is better. This opportunity is possible because all electrical engineering study programs are characterized by the same clump of knowledge and the needs of the industrial world, especially in North Sumatra. graduates who are also not much different, namely, require graduates of electrical engineering who are innovative, can work with teams and have the ability to solve problems by thinking critically in the field of electrical engineering. The Independent Learning Policy of the Independent Campus is an opportunity to provide solutions to these demands[8]. The Independent Campus policy is part of a form of higher education that is more flexible and measurable in developing an innovative learning culture, having scientific freedom according to student needs, as mandated in Permendikbud No. 3 of 2020 concerning National Higher Education Standards. A strategy is needed that is implemented through optimizing the independent campus policy through strengthening the consortium to build a digital learning environment so that the concept of digitizing learning through a GUI-based simulation program is proposed in research. Short circuit fault modeling and analysis implemented in learning is built through bus impedance matrix modeling, to improve student skills in utilizing computer technology in learning [9].

II. Methods

A. Simulation Program design stages

Figure 1, shows the process of preparing the short circuit fault calculation program. Starting from the system data on the inline diagram, then observing the positive, negative and zero sequence data, which will be entered in the simulation GUI. The ZBUS Matrix Model is used in the program design to determine the value of the short circuit impedance by observing the diagonal of the ZBUS matrix. It must be ensured that the calculated value of the ZBUS diagonal matrix is positive, otherwise it is necessary to review the system reactance data entry in the simulation. If it is positive, then the calculated fault current will be valid.

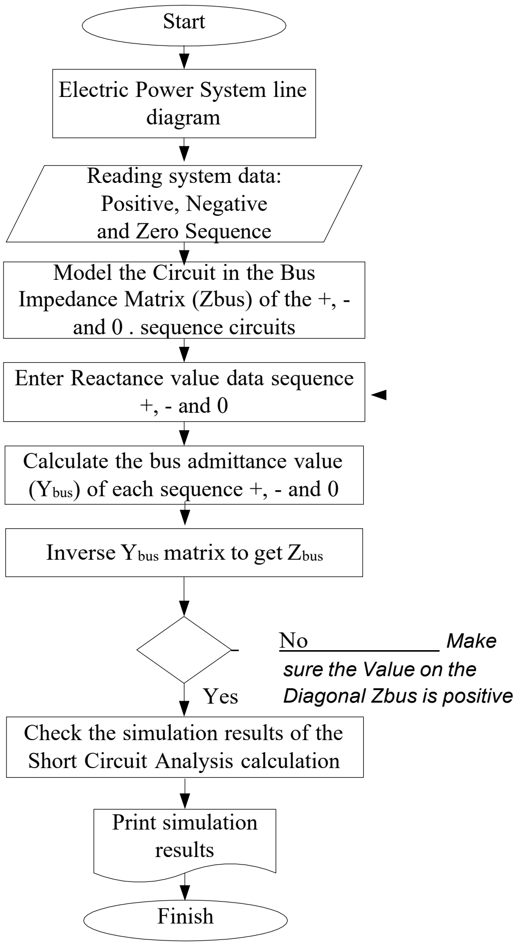


Figure 1 Stages of short circuit simulation program design

B. GUI Layout-Short Circuit Calculation Simulation

Figure 2 shows the stages of compiling a simulation program. At the beginning of the process of compiling the Matlab GUI-based programming, an input box is created via the inspector-matlab.ui.control table settings for enter the reactance value data from the inline diagram of each positive, negative and zero sequence component shown in figure 5.

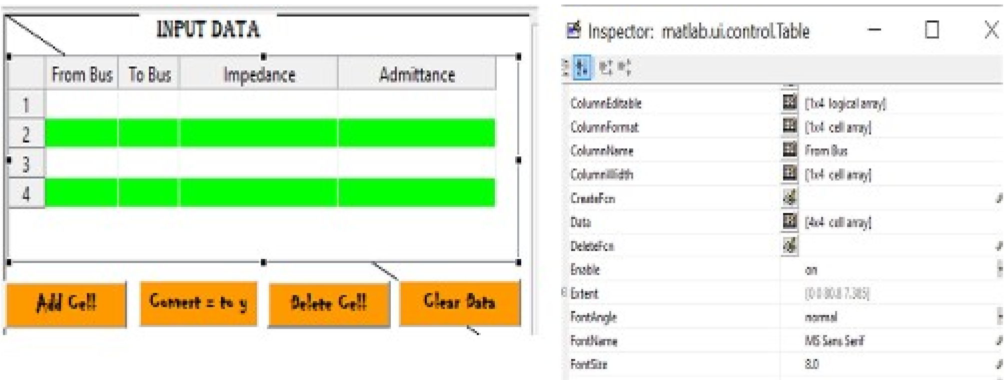


Figure 2 Input table for Impedance and Adimtance data

In addition, on the GUI display, the need for interference selection is designed based on the type of disturbance. namely: three-phase fault, single-phase ground fault, two-phase fault and two-phase ground fault. The simulation result text column with the fault current value in Pu units and the total fault current will display the simulation results, after the simulation process is carried out through the push button, as shown in figure 3.

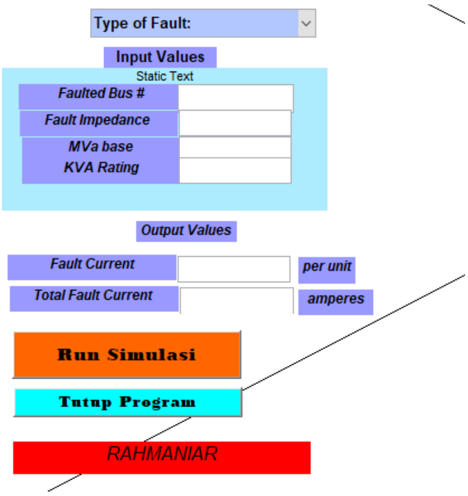
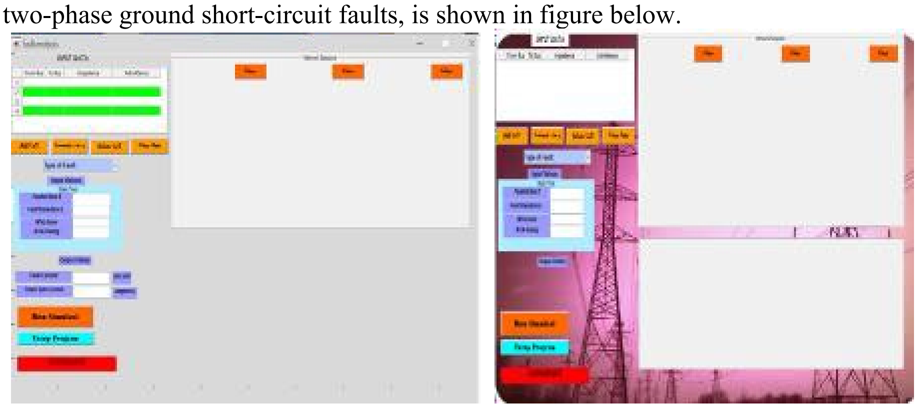


Figure 3 Fault type button Short circuit and run simulation

The overall interface design for the calculation of three-phase short-circuit faults, single-phase-to-ground, two-phase and two-phase ground short-circuit faults, is shown in figure below.



III. Result and Discussion

A. System Data

11 Bus electric power system with 3 generator units as a plant for the Bus Electric Power System Simulation experiment. The power system line diagram is shown in figure 4

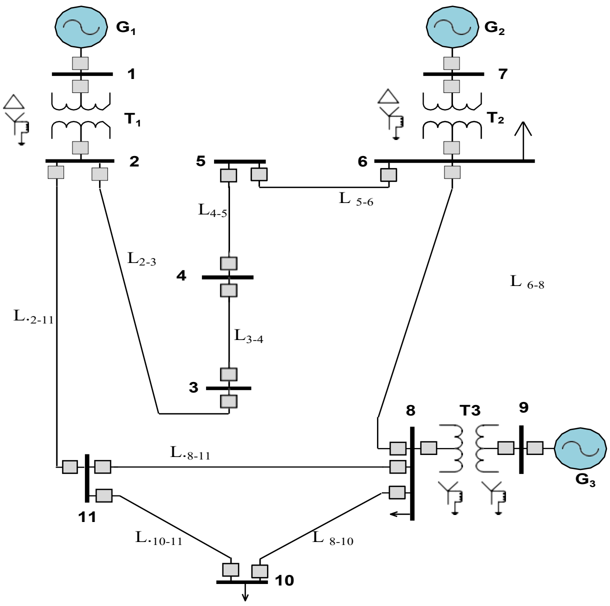


Figure 4 11 Bus power system diagram

B. Data Generator:

The generator data is given in table 1.

Table 1 Generator data

Item	Voltage Rating	X_1 (pu)	X_2 (pu)	X_0 (pu)	X_n (pu)
Rating MVA= 100 MVA					
G_1	20 KV	0,2	0.2	0.05	0.03
G_2	13.8 KV	0.2	0.2	0.05	0.03
G_3	13.8 KV	0.2	0.2	0.05	0.03

C. 4.2. Line and Transformer Data.

Line and transformer data are shown in table 2

Table 2 Line and Transformer Data.

Item	Voltage (KV)	X_1 (pu)	X_2 (pu)	X_0 (pu)
Rating MVA=100 MVA				
T_1	20/150	0.05	0.05	0.05
T_2	20/150	0.05	0.05	0.05
T_3	20/150	0.05	0.05	0.05
$L_{5\text{-}6}$	150	0.05	0.05	0.05
$L_{2\text{-}3}$	150	0,10	0,10	0.30
$L_{3\text{-}4}$	150	0.05	0.05	0.05
$L_{4\text{-}5}$	150	0,10	0,10	0.30
$L_{6\text{-}8}$	150	0,10	0,10	0.30
$L_{8\text{-}11}$	150	0.40	0.40	0.90
$L_{8\text{-}10}$	150	0.40	0.40	0.90
$L_{2\text{-}11}$	150	0.40	0.40	0.90
$L_{10\text{-}11}$	150	0.40	0.40	0.90

D. Data analysis

In the sample data analysis test, manual analysis was carried out (hand analysis) then continued with testing using a short circuit calculation simulation using the Matlab GUI. This is to guarantee the validity of the program script that is entered in the ui-control GUI matlab is correct. Analysis samples tested from the media, through the calculation of three-phase short-circuit faults with the assumption that if there is a fault on the 8-bus. Suppose the system has a short circuit on the 8. bus, condition at the time of disturbance, $\bar{V}_0 = \bar{V}_2 = 0$, and $\bar{I}_0 = \bar{I}_2 = 0$, Short circuit current on the faulty Bus:

$\bar{I}_i^1 = \dfrac{\bar{E}}{\bar{Z}_f + \bar{z}_{ii}}$ and Voltage on each bus under fault conditions: $\bar{V}_j = \bar{E} - \bar{z}_{ji}^1 \bar{I}_i^1$. From the results of calculations by hand analysis, using the Zbus matrix model, at bus8-8 the short circuit impedance value is equivalent to j0.1205, With thevenim impedance value of 0.1 pu then obtained

$$I_8^{012}(F) = \begin{bmatrix} 0 \\ \dfrac{1}{j0.1205 + 0.1} \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ -j4,535 \\ 0 \end{bmatrix}$$

$$I_8^{abc}(F) = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} 0 \\ -j4,535 \\ 0 \end{bmatrix} = \begin{bmatrix} 4,535\angle -90 \\ 4,535\angle -150 \\ 4,535\angle 30 \end{bmatrix}$$

The voltage at each bus is calculated and for the fault current through bus i to bus j, successively, the results can be seen in table 3.

Table 3 Analysis Results of bus fault current i to j and fault voltage (pu)

Voltage on Bus -pu-	**Fault current (bus-i to bus-j) -pu-**
$V_1(F) = 1 - j0,0403(-j4,535) = 0,8172$	$I_{12}(F) = \dfrac{V_1(F) - V_2(F)}{z_{12}} = \dfrac{0.8172 - 0.7718}{j0.05} = j0.908$
$V_2(F) = 1 - j0,0503(-j4,535) = 0,77718$	$I_{23}(F) = \dfrac{V_2(F) - V_3(F)}{z_{23}} = \dfrac{0.7718 - 0.7279}{j0.10} = j0.439$
$V_3(F) = 1 - j0,060(-j4,535) = 0,7279$	$I_{34}(F) = \dfrac{V_3(F) - V_4(F)}{z_{34}} = \dfrac{0.7279 - 0.7061}{j0.05} = j0.436$
$V_4(F) = 1 - j0,0648(-j4,535) = 0,7061$	$I_{45}(F) = \dfrac{V_4(F) - V_5(F)}{z_{45}} = \dfrac{0.7061 - 0.6625}{j0.10} = j0.436$
$V_5(F) = 1 - j0,0744(-j4,535) = 0,6625$	$I_{56}(F) = \dfrac{V_5(F) - V_6(F)}{z_{56}} = \dfrac{0.6625 - 0.6408}{j0.05} = j0.434$
$V_6(F) = 1 - j0,0792(-j4,535) = 0,6408$	$I_{76}(F) = \dfrac{V_7(F) - V_6(F)}{z_{76}} = \dfrac{0.7129 - 0.6408}{j0.05} = j1.4426$
$V_7(F) = 1 - j0,0633(-j4,535) = 0,7129$	$I_{68}(F) = \dfrac{V_6(F) - V_8(F)}{z_{68}} = \dfrac{0.6408 - 0.4535}{j0.05} = j1.8731$
$V_8(F) = 1 - j0,1205(-j4,535) = 0,4535$	$I_{8-G}(F) = \dfrac{V_8(F)}{z_f} = \dfrac{0.4535}{j0.10} = j4.535$
$V_9(F) = 1 - j0,094(-j4,535) = 0,5737$	$I_{98}(F) = \dfrac{V_9(F) - V_8(F)}{z_{98}} = \dfrac{0.5737 - 0.4535}{j0.05} = j2.404$
$V_{10}(F) = 1 - j0,1064(-j4,535) = 0,5174$	$I_{10-8}(F) = \dfrac{V_{10}(F) - V_8(F)}{z_{10-8}} = \dfrac{0.5174 - 0.4535}{j0.40} = j0.1597$
$V_{11}(F) = 1 - j0,1064(-j4,535) = 0,5809$	$I_{11-8}(F) = \dfrac{V_{11}(F) - V_8(F)}{z_{11-8}} = \dfrac{0.5809 - 0.4535}{j0.40} = j0.3185$
	$I_{11-10}(F) = \dfrac{V_{11}(F) - V_{10}(F)}{z_{11-10}} = \dfrac{0.5809 - 0.5174}{j0.40} = j0.1587$

Table 3. shows the results of the analysis of the i to j bus fault currents and the fault voltage in units per unit. This manual analysis calculation will be verified with GUI media, as a media tool used in the learning of electrical engineering students. In manual calculations, when there is a short-circuit fault on bus-8, the fault current is:

$$I_{8-G}(F) = \frac{V_8(F)}{z_f} = \frac{0.4535}{j0.10} = j4.535$$

The simulation results of the calculation of the magnitude of the short circuit fault on bus-8 using the GUI Media that has been designed, show that the value of the fault current is x (see Figure 6), thus the GUI is validated, the value of the fault magnitude is the same. with these results it can be stated early that the GUI Valid media is used in power system analysis learning, to calculate the amount of short circuit fault current.

Figure 5 Simulation results of 3-phase short circuit fault calculation using GUI

E. GUI Media Validation by Media Expert

The media validation test phase by experts is carried out after a short-circuit simulation media using a GUI is created, then validated by four experts, 2 experts in the field of electrical engineering and 2 other experts in the field of computer information systems. The media validation process is carried out by discussion or direct interviews with experts regarding improvements to be made by means of media design GUI learning is consulted with experts first, then the simulation program is assessed by experts who understand the principles of short circuit analysis and GUI-based media development. The results of the expert assessment are then simulated with the matlab simulink device to see the validity by the experts, as a way to see the degree of trust in the media that will be used in learning. The calculation of the media validity test simulation by the expert is shown in figure 6.

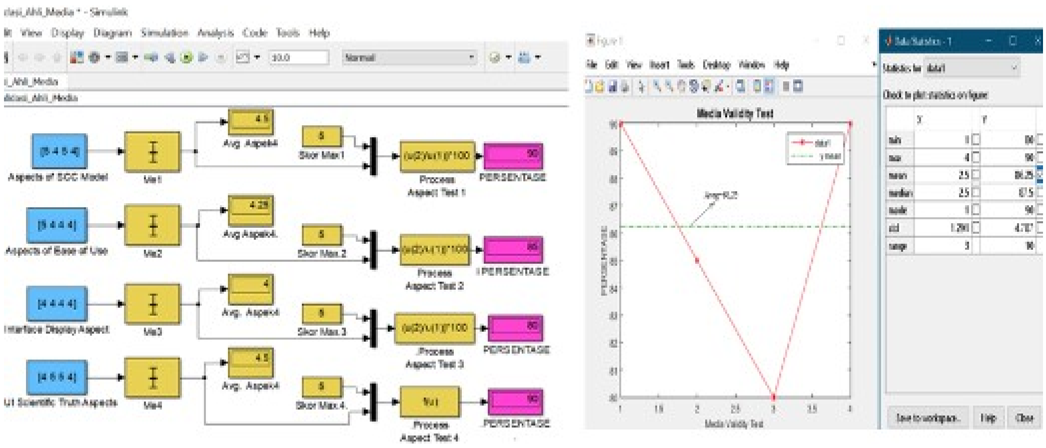


Figure 6 GUI Media Validity Test Simulation

Figure 6 shows a simulation of the GUI media validity analysis that was assessed by experts, using the Aiken'v theorem. From the simulation results, the average value of the GUI which includes aspects of the model, aspects of ease of use, GUI appearance and GUI scientific data shows an average validity value of 0.8625 in the very good category. In line with the results of the validity assessment by the three validators from Elmi's research [12], in the results of his research using the

Aiken index, the value of V = 0.89 shows that the learning media website-based chemistry 2 APK builder on acid-base solution material is very valid to be tested

IV. Conclusion

From the results of the research study on GUI development for learning electric power system analysis, it can be concluded:

1. GUI for short circuit analysis on the electrical power system that is designed, has ease of use, has been compared between the results of manual calculations (hand analysis) using a GUI for the case of an 11 bus electric power interconnection system, showing valid results, the fault current value is j 4,536 pu for three-phase short-circuit fault, meaning that the fault current value is 4.536 times greater than the nominal current.
2. The test results on the GUI media simulation of short circuit analysis calculations, which were plotted using Matlab software, from the assessment of 4 experts, showed 4 aspects of the GUI program criteria that had been designed, with the aiken'v formulation approach showing valid media used in short circuit analysis learning with Aiken index obtained a value of 0.8625, very good category.

VII. Acknowledgement

The article entitled: Digital Simulation of Short Circuit Current Calculation Using Graphical User Interface for Learning Media Electric Power System Analysis, supported by the Ministry of Education, Research and Technology and Lembaga Pengelola Dana Pendidikan (LPDP) through a research fund based on a contract: 058/E. 41/AK.04.RA/ 2021

References

[1] C. P. Benoît de METZ-NOBLAT, Frédéric DUMAS, “Calculation of short circuit currents,” *Prot. Electr. Distrib. Networks*, no. 158, pp. 11–41, 2021, doi: 10.1049/pbpo180e_ch2.

[2] S. Ghavifekr and W. A. W. Rosdy, “Teaching and learning with technology: Effectiveness of ICT integration in schools,” *Int. J. Res. Educ. Sci.*, vol. 1, no. 2, pp. 175–191, 2015, doi: 10.21890/ijres.23596.

[3] A. P. Gilakjani, “A Review of the Literature on the Integration of Technology into the Learning and Teaching of English Language Skills,” *Int. J. English Linguist.*, vol. 7, no. 5, p. 95, 2017, doi: 10.5539/ijel.v7n5p95.

[4] J. Higgs, R. Barnett, S. Billett, M. Hutchings, and F. Trede, *Practice-based education: perspectives and strategies*. 2012.

[5] IEEE Std 242, *IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems*, vol. 2001. 2001.

[6] R. A. Jabr and I. Džafić, “A Fortescue Approach for Real-Time Short Circuit Computation in Multiphase Distribution Networks,” *IEEE Trans. Power Syst.*, vol. 30, no. 6, pp. 3276–3285, 2015, doi: 10.1109/TPWRS.2014.2376198.

[7] K. S. John King, Joseph South, *Reimagining The Role of Technology in Education*, vol. 9, no. 1. 1981.

[8] E. van Laar, A. J. van Deursen, J. A. van Dijk, and J. de Haan, “The Essential Skills of 21 st Century Classroom – President Barak Obama Research,” *Sage Open*, vol. 10, no. 1, 2020, doi: 10.13140/RG.2.2.36190.59201.

[9] A. Junaidi, J. Rambe, R. Salman, R. Rahmaniar, and R. Rosnelli, “Power System Modeling and Network Simulation: The Content Validity of the E-MAP Model in Electric Power Transmission Technology,” pp. 1–7, 2020, doi: 10.4108/eai.16-11-2019.2293110.