Realtime hybrid offline-online power loss analysis-based Simulink simulation

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ABSTRACT

The power distribution system applied in Indonesia is the radial system. The system is considered to be the simplest and most economical. The bad or good distribution of electrical power can be observed from the quality of the distribution of power supplied. Voltage has to be monitored and kept constant. An analysis was conducted at Bendul Merisi Feeder which has 11 buses, to find the value of supplied power also the value of voltage drop of each bus. The Simulink method is used to simulate and analyze active and reactive power at each cluster. Based on the result of the simulation analysis, the average was obtained by adding up electrical power received every hour, then dividing by 10, the number of buses connected to the load. The smallest average of active power supplied to each bus happened at 09.00 a.m., i.e. 112137.94 VA. The biggest value of active power supplied to each bus happened at 1.00 p.m., i.e. 115129.05 VA. The total voltage drop that occurred in the distribution supply was 224 volts or 1.12% out of 20 kV supplied, indicating that the supply of voltage was according to the standardized rule implemented by PLN (State Electricity Company), i.e. the voltage drop should not exceed the maximum of 10%.

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1. INTRODUCTION

Electrical energy is a form of energy that has a vital role in human daily activities. The rate of population growth that continues to increase is directly proportional to the increase in the need for energy capacity every year. This raises new problems for electricity providers who are required to continue to improve the continuity of good electrical power supply services. As a provider of electricity, it is not only generated but must be distributed to consumers. The distribution of electrical energy that starts from the electricity provider or generator and then continues with the transmission system and ends with the usage by consumers must be efficient, effective, and reliable [1].

The trend of the current power generation system is the formation of an interconnection system between one power plant and another to increase the reliability of the electric power system. The reliability of a power plant or electricity provider can be easily determined, namely by whether there are frequent blackouts or power outages around the power plant or substation. The way to prevent blackouts or voltage drops is to monitor every point of the power transmission line, of course, this supervision must be in real-time or every time and every second. In line with technological advances, equipment in the distribution and transmission network undergoes modernization and automation. There is a tool that can monitor and monitor every second accurately, namely the phasor measurement unit (PMU). This PMU will be able to monitor the power, current, and voltage flowing in the distribution system [2], [3].

In this study, an online and offline monitoring system simulation was designed with the data generated after determining the number of PMUs needed. Which will be simulated using the MATLAB Simulink program and using Arduino. So, it is expected to show the value of voltage, power, and the current flowing in the system. The location object that will be used in Bendul Merisi Feeder consists of 11 buses and contributed to supplying electric power to South Surabaya Zone. The power distribution flow will be analyzed and the result of the analysis will be concluded and explained.

2. THE COMPREHENSIVE THEORETICAL BASIS

2.1. Predeceased research

This paper provides an experiment of watt meter simulation to measure electrical parameters such as active power, reactive power, power factor, and consumed energy [4], [5]. A watt meter is an essential device to measure the energy consumption of each consumer house [6]–[8]. Therefore, the purpose of this research is to design and analyze watt meter performance using three-phase system modelling. Many types of load including resistive load (R load), resistive inductive (RL load), and resistive capacitive (RC load) have been studied to analyze energy measurement performance [9]–[12]. In this research, energy meter modelling is designed using Simulink MATLAB [13]–[15]. The watt meter model consists of a voltage block, current block, load block, power factor block, and energy measurement block. Results received from the simulation can be precisely visible in this paper. Results between simulation and calculated load show that watt meter can receive high accuracy and efficiency [16].

In this study, an analysis of electrical power distribution will be carried out on Bendul Merisi Feeder. This analysis was carried out on every bus in Bendul Merisi Feeder which has given phasor measurement units (PMU) to observe voltage and current in each every bus by grouping into several clusters which will be analyzed by using Simulink to achieve active and reactive power value in each bus. Electrical power analysis is also carried out by using ETAP so that the results of the analysis can be compared between mathematical calculation analysis, ETAP analysis, and also simulation analysis [17], [18]. The Analysis results from ETAP then can be observed through other platform of device using internet of things [19]–[23].

2.2. Energy loss in distribution network

The distribution system is the system in which the power flow is connected directly to the load or directly to the customers. The distribution system transmits power from the main transmission directly to each consumer point. The voltage drop flows distribution system is shown in Figure 1.

2.3. Voltage drop

Voltage drop is the amount of voltage that is lost during the distribution process through a conductor. Voltage drop V will be greater if the current flowing in the conductor is getting bigger. Voltage drop can be analyzed by (1).

$$\Delta V = |V_S| - |V_r| \tag{1}$$

ΔV is the difference between the voltage at sending end and the voltage at receiving end. Following the voltage standard determined by PLN, network designs were made so that the drop voltage at the receiving end is 10%. With voltage at sending end (V_k) and voltage at receiving end (V_T), voltage drop redefined by (2).

$$\Delta V = (V_k) - (V_T) \tag{2}$$

Due to conductor resistance, the voltage at receiving end ($V_r = V_T$) will be smaller than the voltage at sending end ($V_s = V_k$), so voltage drop is also the difference between voltage at sending end and voltage at receiving end. Voltage drop relatively called voltage regulation V_R and defined by (3).

$$V_R = \frac{V_S - V_r}{V_r} \times 100\% \tag{3}$$

With V_s as voltage at sending end and V_r as the voltage at receiving end.

Bus injection to branch current (BIBC) and branch current to bus voltage (BCBV) matrixes formed based on the distribution system topology structure below 2. BIBC matrix defines a relation between bus injection current and branch current. BCBV matrix defines a relation between branch current and bus voltage. Figure 2 shows the single line diagram example of the branched bus.

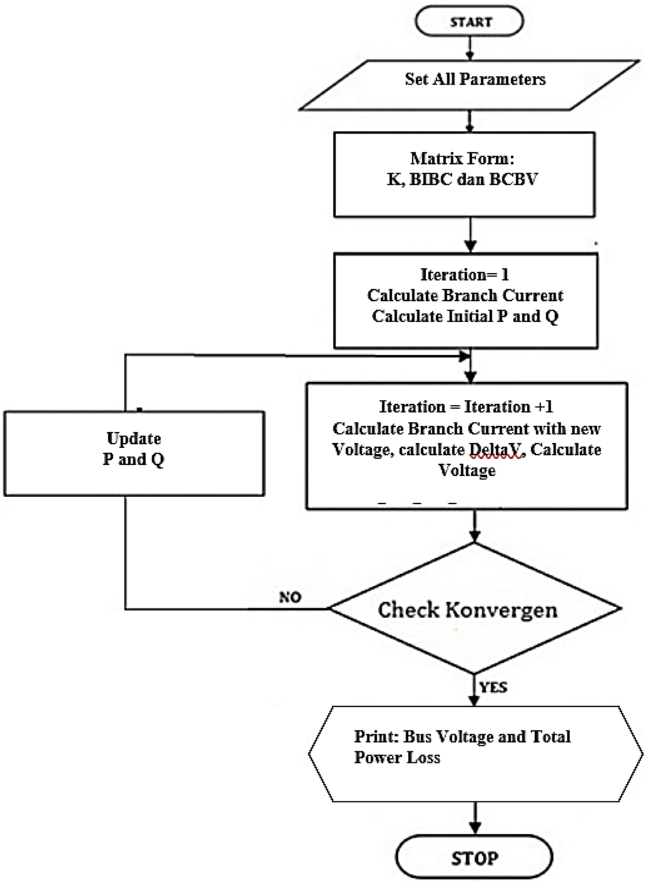

Figure 1. Flow chart of voltage drop flow [24]

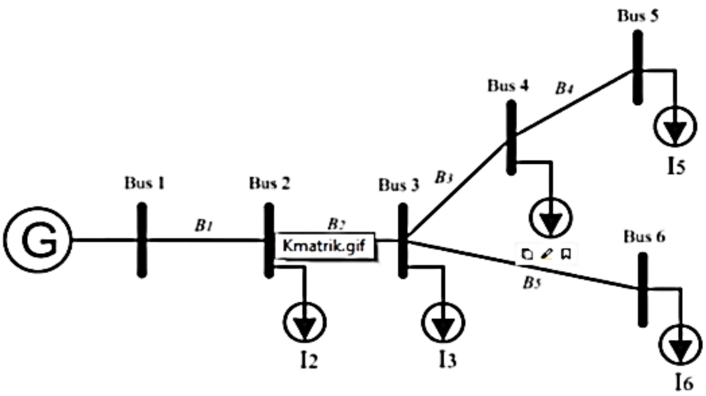

Figure 2. Single line diagram example [25]

From the displayed single line diagram then get an equation to form a BIBC matrix, by using the Kirchoff Law of current (Kirchoff Current Law).

$$B_1 = I_2 + I_3 + I_4 + I_5 \tag{4}$$

$$B_2 = I_3 + I_4 + I_5 + I_6 \tag{5}$$

$$B_3 = I_4 + I_5 \tag{6}$$

$$B_4 = I_5 \tag{7}$$

$$B_5 = I_6 \tag{8}$$

By equations, concluded following BIBC matrix form (9).

$$\begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \end{bmatrix} \tag{9}$$

Number 1 expresses the relation between the current and channel while number 0 express no relation between both. By simplification will be received (14).

$$[B] = [BIBC][I] \tag{10}$$

Then the equation of voltage drop in each bus:

$$V_2 = V_1 - B_1 \times Z_{12} \tag{11}$$

$$V_3 = V_1 - B_1 \times Z_{12} - B_2 \times Z_{23} \tag{12}$$

$$V_4 = V_1 - B_1 \times Z_{12} - B_2 \times Z_{23} - B_3 \times Z_{34} \tag{13}$$

$$V_5 = V_1 - B_1 \times Z_{12} - B_2 \times Z_{23} - B_3 \times Z_{34} - B_4 \times Z_{45} \tag{14}$$

$$V_6 = V_1 - B_1 \times Z_{12} - B_2 \times Z_{23} - B_5 \times Z_{36} \tag{15}$$

By equations, concluded following BCBV matrix form:

$$\begin{bmatrix} V_1 - V_2 \\ V_1 - V_3 \\ V_1 - V_4 \\ V_1 - V_5 \\ V_1 - V_6 \end{bmatrix} = \begin{bmatrix} Z_{12} & 0 & 0 & 0 & 0 \\ Z_{12} & Z_{23} & 0 & 0 & 0 \\ Z_{12} & Z_{23} & Z_{34} & 0 & 0 \\ Z_{12} & Z_{23} & Z_{34} & Z_{45} & 0 \\ Z_{12} & Z_{23} & 0 & 0 & Z_{36} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} \tag{16}$$

By simplification will be received the (17).

$$[\Delta V] = [BCBV][B] \tag{17}$$

Then equation to determine ΔV as (18).

$$[\Delta V] = [BCBV][BIBC][I]$$

$$[\Delta V] = [DLF][I] \tag{18}$$

Matrix $[\Delta V]$ is to determine the voltage drop from the source bus to the load bus in the system. By receiving the BIBC matrix, the BCBV matrix and ΔV will be able to calculate the voltage value in each bus. The equation to calculate the voltage value in each bus is as (19).

$$[V_i] = [V_1] - [\Delta V] \tag{19}$$

3. RESEARCH METHOD

3.1. System block diagram

Block diagram describing the operation of the monitoring system and online-offline system using Simulink and Arduino. Figure 3 shows the system block diagram. Hybrid online-offline system in Bendul Merisi Feeder distribution network consists of five main blocks, such as feeder data which is received voltage and current. Analog signal input is used to represent the current and voltage value of data. Arduino is utilized to read analog signals resulting from 5 V voltage input which will be input in the designed simulation. Simulink simulation, result, feeder data sample received after detecting PMU used will be simulated in Simulink. Offline data is received from feeder data previously designed and simulated with ETAP, then the next data, online data, is received by sensor input of hardware. Both data will be simulated with Simulink.

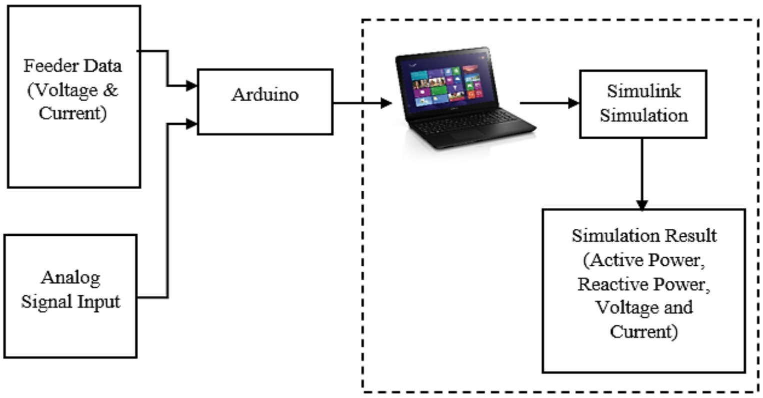

Figure 3. System block diagram

3.2. Feeder data

Processed data of research comes from one of the Bendul Merisi Feeders. The feeder is concentrated in Wonokromo main substation with radial distribution system. Utilization of the radial system dated back to the first distribution network system in Indonesia. Bendul Merisi Feeder consists of 11 buses with 1 main bus directly supplied by the main substation. Figure 4 shows the single line diagram of the feeder.

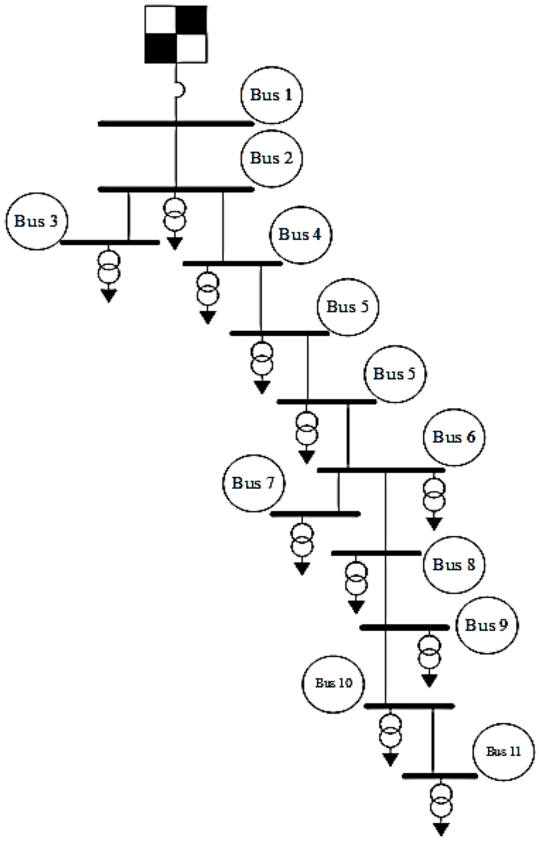

Figure 4. Single line diagram of Bendul Merisi Feeder

3.3. Online offline hybrid system flowchart

Hybrid online offline system process flow is separated into two scenarios, which are: data and designing and testing on ETAP and hardware, then hybrid system designing in Simulink into hybrid system testing of system software and hardware in Simulink. The received database is data from ETAP design so the value of power, voltage, and current in each chosen bus is compatible with the single line diagram of the Bendul Merisi Feeder. Later, designed hardware referred to values displayed by PMU in each bus.

Data will be processed by ETAP to receive values of system power flow. With ETAP design also to be received values of current, voltage, active power, and reactive power detected in each bus are adjusted to single line diagram. The values will become the database source of the simulation. Figure 5 shows the test flowchart.

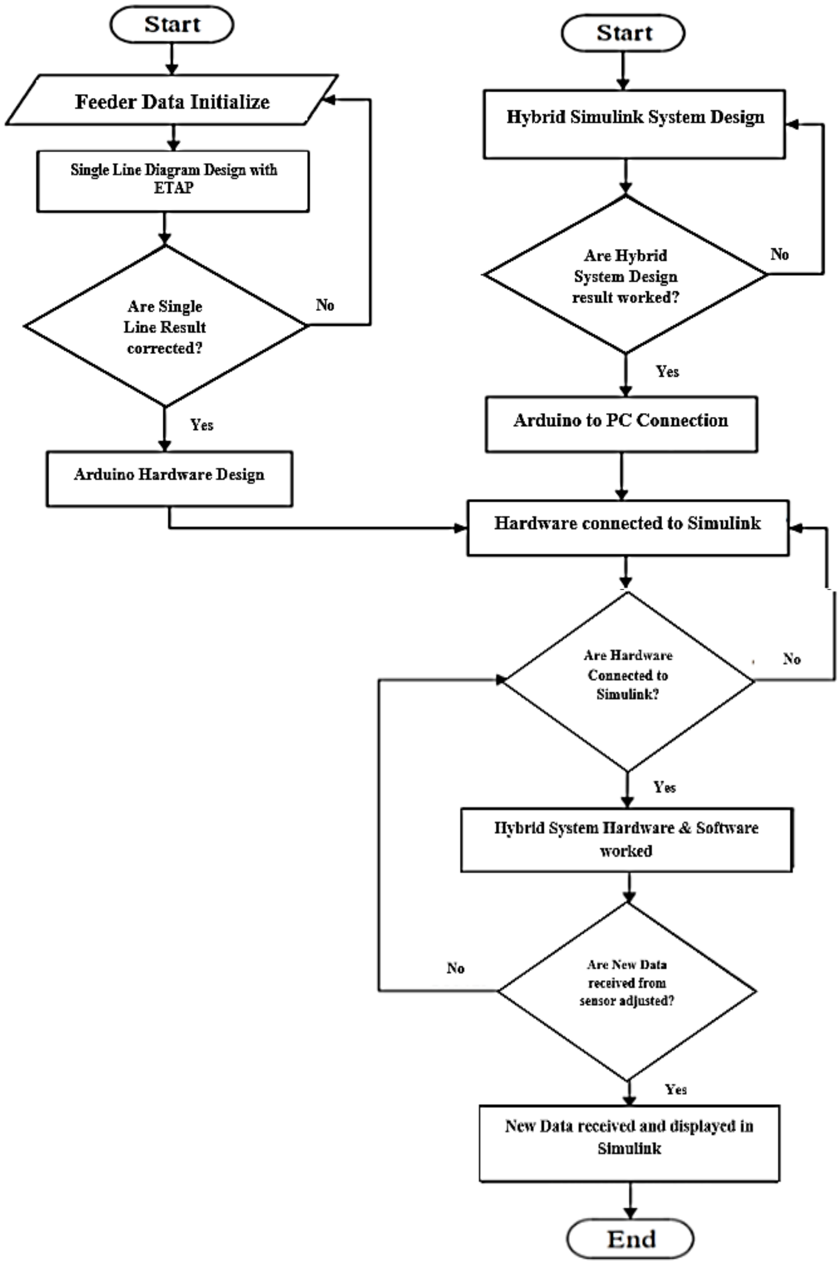

Figure 5. Data designing and testing also hardware designing flowchart

3.3.1. Hardware designing and testing

Potentiometer utilized to detect 5 V voltage input which will be converted into an analog signal where 0 at 0 V and 1023 at 5 V. Analog signal transmitted to ADC port of Arduino connected to personal computer. ADC signal processed with Simulink to receive voltage and current value compatible or close to data from Bendul Merisi Feeder to find active power, and reactive power in each bus of each chosen cluster. Ten potentiometer to receive 5 V input supply from Arduino utilized to detect voltage input from Arduino. Analog signal utilized as input value to be processed in Simulink software so voltage and current value are received and compatible to values of data from Bendul Merisi Feeder.

3.4. Calculation analysis procedure

The calculation analysis procedure: i) Step 1: Construct a single line diagram in ETAP complete with line impedance and load; ii) Step 2: Record voltage, current active power, and reactive power data received from the ETAP simulation run; iii) Step 3: Calculate with power formula to find active power (P) and reactive power (Q) using data from steps 1 and 2; iv) Step 4: Calculate the total power received from step 3 with the total power calculation of each cluster; v) Step 5: Calculate the voltage drop of the feeder distribution system with load data and impedance value; and vi) Step 6: Design estimation simulation using Simulink with calculated data. Figure 6 shows the Simulink software design.

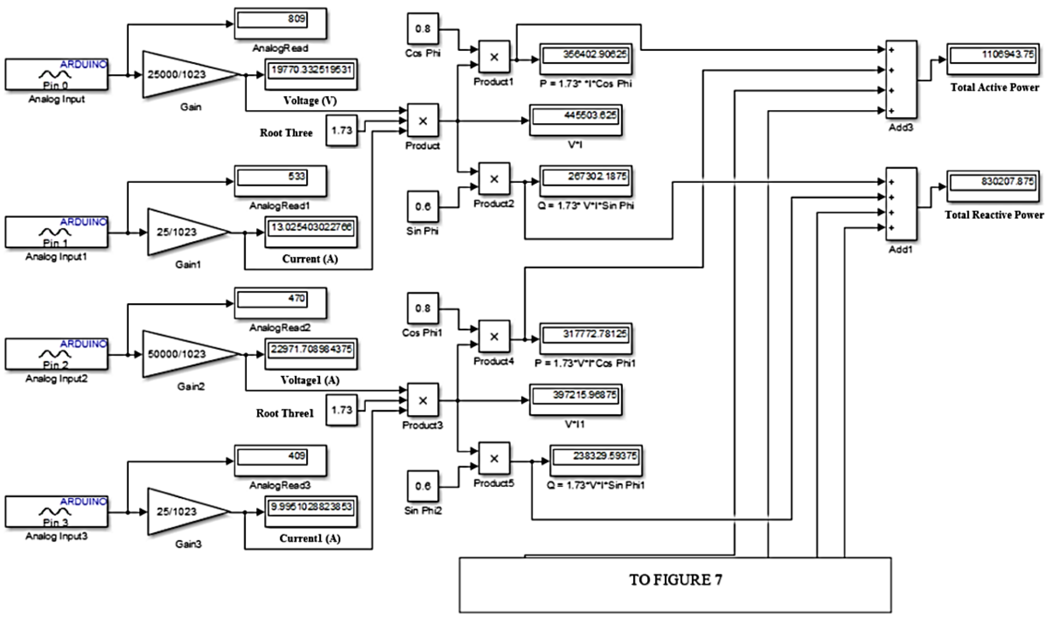

Figure 6. Overall Simulink software design part 1

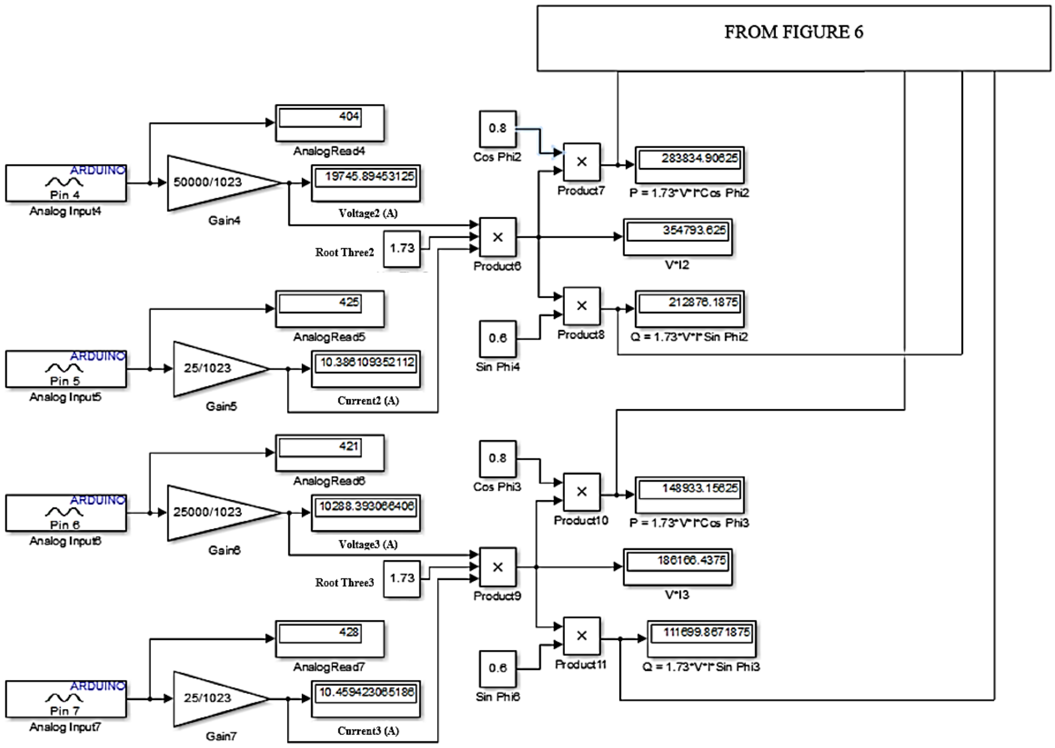

Figure 7. Overall Simulink software design part 2

4. RESULTS AND DISCUSSION

4.1. Load flow analysis using ETAP

According to the [25] research analysis from simulation started with using ETAP to analyze the load flow of the Bendul Merisi Feeder. Load flow results from initial data received with the condition where voltage assumed in balance with no load so the voltage used are 20 kV. Peak load data with line impedance according to the research of Mochamad Ali Fichan Baihaqi, the following Table 1 shows load data and line impedance that will be analyzed and simulated to find active power (P) and reactive power (Q) in each bus. There is $\sin\varphi$ value of 0.6, which was received by the following calculation:

$$\cos\varphi = 0.8 \quad (20)$$

$$\varphi = \arccos 0.8 = 36.87° \quad (21)$$

$$\sin\varphi = \sin 36.87° = 0.6 \quad (22)$$

Table 1. Peak load value based on measurement from Bendul Merisi Feeder

Bus	Line Impedance	Bus	S (kW)	V (Volt)	I (Ampere)	$\cos\varphi$	$\sin\varphi$
Z12	0.07861+0.02931i	2	745	19913	21.4	0.8	0.6
Z23	0.05553+0.02071i	3	208	19910	6	0.8	0.6
Z24	0.19424+0.07244i	4	496	19869	14.2	0.8	0.6
Z45	0.09788+0.03650i	5	483	19832	13.8	0.8	0.6
Z56	0.23836+0.08889i	6	319	19801	9.1	0.8	0.6
Z67	0.39681+0.14724i	7	689	19793	19.7	0.8	0.6
Z68	0.2776+0.10355i	8	290	19783	8.3	0.8	0.6
Z89	0.04869+0.01816i	9	455	19768	13	0.8	0.6
Z910	0.13845+0.05163	10	350	19760	10	0.8	0.6
Z1011	0.27005+0.10071i	11	363	19755	10.4	0.8	0.6

4.2. Calculation analysis with power triangle

The next step is to find active power and reactive power value by using mathematical calculation using the power triangle method described with the formula:

$$P = \sqrt{3}\, VI \cos\varphi \quad (23)$$

$$Q = \sqrt{3}\, VI \sin\varphi \quad (24)$$

By the rules of PLN, it is not allowed to connect the load to bus 1, since bus 1 becomes the connector between Line from the main substation to the load feeder. Therefore, loads started and connected to bus 2, so the load calculation started from bus 2 to bus 11 on Bendul Merisi Feeder transmission system. From the described formula above, here is the calculation result of active power and reactive power. Example: bus 2

$$P = \sqrt{3} \times 19913 \times 21{,}4 \times 0.8 = 589.775\ kW$$

$$Q = \sqrt{3} \times 19913 \times 21.4 \times 0.6 = 442.331\ kVAR$$

Bus 3 $P = \sqrt{3} \times 19910 \times 6 \times 0.8 = 165.333\ kW$

$$Q = \sqrt{3} \times 19910 \times 6 \times 0.6 = 123.999\ kVAR$$

Voltage value can be changed to pu unit by knowing the measured percentage value (%volt) and then divided by 100%, as the following formula:

$$Voltage\ (p.u.) = \frac{Measured\ Voltage\ (\%)}{100\%}$$

and with the formula above, the voltage data is calculated in Table 2.

The next step is Table 2 to enable ETAP simulation to get voltage and current values that flow in each bus of Bendul Merisi Feeder and also active power (P) and reactive power (Q). The simulation result of ETAP will be utilized to calculate total active power and reactive power in each cluster. Table 3 shows the ETAP simulation running result of voltage and current also active and reactive power from received data after load value input in each bus.

From Table 3 is the bus member data of each cluster with the calculation of total active power (P) and reactive power (Q) on each cluster. P and Q value data is shown in the following Table 4 of bus member data in each cluster:

- Cluster 1

On first cluster, bus members including bus 2, bus 3, and bus 4. Here is the calculation:

$$P_{cluster1} = P_{bus2} + P_{bus3} + P_{bus4} = 591\ kW + 165\ kW + 392\ kW = 1148\ kW$$

$$Q_{cluster1} = Q_{bus2} + Q_{bus3} + Q_{bus4} = 443\ kVar + 124\ kVar + 294\ kVar = 851\ kVar$$

- Cluster 2

On second cluster, bus members include bus 5, bus 6, bus 7, and bus 8. Here is the calculation:

$$P_{cluster2} = P_{bus5} + P_{bus6} + P_{bus7} + P_{bus8} = 380\ kW + 250\ kW + 540\ kW + 227\ kW = 1137\ kW$$

$$Q_{cluster2} = Q_{bus5} + Q_{bus6} + Q_{bus7} + Q_{bus8} = 285\ kVar + 188\ kVar + 405\ kVar + 170\ kVar = 1048\ kVar$$

- Cluster 3

On third cluster, bus members including bus 9, bus 10, and bus 11. Here is the calculation:

$$P_{cluster3} = P_{bus9} + P_{bus10} + P_{bus11} = 356\ kW + 273\ kW + 283\ kW = 912\ kW$$
$$Q_{cluster3} = Q_{bus9} + Q_{bus10} + Q_{bus11} = 267\ kVar + 205\ kVar + 213\ kVar = 685\ kVar$$

Table 2. Voltage Data in p.u. unit

Bus	Load (kVA)	V (Volt)	Measured voltage (%)	Voltage (p.u.)
2	745	19913	99.57%	0.9957
3	208	19910	99.55%	0.9955
4	496	19869	99.35%	0.9935
5	483	19832	99.16%	0.9916
6	319	19801	99.01%	0.9901
7	689	19793	98.97%	0.9897
8	290	19783	98.92%	0.9892
9	455	19768	98.84%	0.9848
10	350	19760	98.80%	0.9880
11	363	19755	98.78%	0.9878

Table 3. ETAP Simulation running result data

Bus	Load (kVA)	Voltage (V)	Current (A)	Active power (P)	Reactive power (Q)
1	0	19968	125.8	3486	2606
2	745	19913	21.4	591	443
3	208	19910	6	165	124
4	496	19869	14.2	392	294
5	483	19832	13.8	380	285
6	319	19801	9.1	250	188
7	689	19793	19.7	540	405
8	290	19783	8.3	227	170
9	455	19768	13	356	267
10	350	19760	10	273	205
11	363	19755	10.4	283	213

Table 4. Bus member data in each cluster

Cluster	Bus member	Total bus	PMU
1	Bus 2, bus 3, and bus 4	3	Bus 2
2	Bus 5, bus 6, bus 7, and bus 8	4	Bus 6
3	Bus 9, bus 10, and bus 11	3	Bus 10

4.3. System simulation test

The next step after active power and reactive power calculation in each cluster is to apply the designed simulation system to Simulink to calculate active power and reactive power in each bus and the total active power and reactive power in each cluster. Simulation result of cluster 1: Figure 7 shows the simulation result for cluster 1 at bus 2 and bus 3. Analog input and analog input1 represent the voltage value and current value of bus 2. Analog input2 and analog input3 represent voltage value and current from bus 3. Table 5 shows the simulation result with each data of voltage, current, active power, and reactive power of each bus.

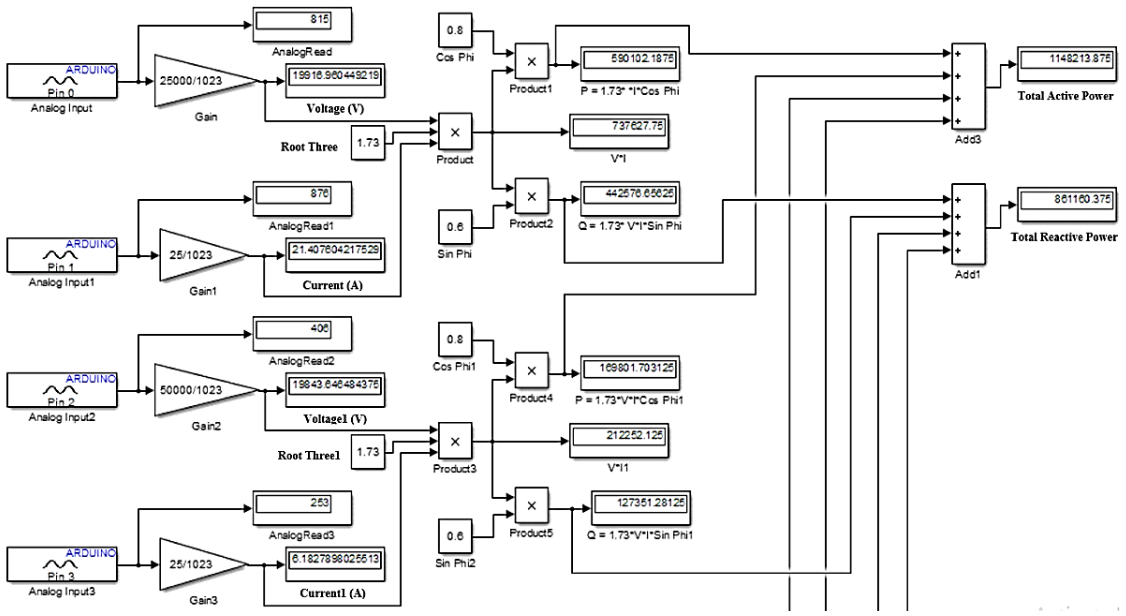

Figure 8. Simulation result for cluster 1 at bus 2 and bus 3

Table 5. Simulation results

Bus	Load (kVA)	Voltage (V)	Current (A)	Active power (P)	Reactive power (Q)
2	745	19916.96	21.41	590102.187	442576.66
3	208	19843.646	6.183	169801.703	127351.281
4	496	19868.084	14.174	389748.125	292311.094
5	483	19819.21	13.81	378734.47	284050.844
6	319	19794.77	9.091	249053.984	186790.484
7	689	19745.894	19.721	538952.437	404214.344
8	290	19770.332	8.235	225342.922	169007.203
9	455	19770.33	13.009	355734.219	266800.687
10	350	19745.894	10.019	273817.219	205362.906
11	363	19745.894	10.41	284502.75	213377.078

4.4. Simulation accuracy analysis

The accuracy analysis purpose is to determine the error level in percentage from the designed simulation and as success determination of the designed simulation. Table 6 is error results received in percentage between the calculation of with the power triangle method and simulation. It is concluded that from Table 6, the average error between mathematical calculation with power triangle method and simulation for active power is 0.435% and for reactive power is 0.426%. Then average error between ETAP running and simulation result is 0.618% for active power and 0.556% for reactive power. This shows that the designed simulation system enables one to do a simulation to find active power value and reactive power in each bus on Bendul Merisi Feeder.

4.5. Voltage drop calculation analysis

After determining the total active power (P) and total reactive power (Q) of each cluster then calculate the voltage drop that occurred while the transmission process with data from Table 3. Drop voltage calculation was utilized to determine loss voltage while the transmission process happened. Here is the drop voltage calculation, voltage relative fall, and voltage phasor fall of each bus:

$$V_k = V_S;\ V_T = V_r;\ \Delta V = V_k - V_r;\ V_R = \frac{V_S - V_r}{V_r} \times 100\%;\ \theta_{maks} = \tan^{-1}\frac{X}{R};\ V_d = I_{11}\,(R\cos\theta + X\sin\theta)$$

From calculation based on the formula above, the voltage drop value determined in the following Table 7.

Table 6. Error result of accuracy comparison between power triangle calculation with simulation

Bus	Load (kVA)	Power triangle calculation					
		Active power		%Error	Reactive power		%Error
		Calculation	Simulation		Calculation	Simulation	
2	745	589775	590102.187	0.055	442331	442576.66	0.056
3	208	165333	169801.703	2.703	123999	127351.281	2.703
4	496	390841	389748.125	0.280	292861	292311.094	0.188
5	483	378775	378734.47	0.011	284082	284050.844	0.011
6	319	249382	249053.984	0.132	187036	186790.484	0.131
7	689	539652	538952.437	0.130	404739	404214.344	0.130
8	290	227251	225342.922	0.840	170438	169007.203	0.839
9	455	355666	355734.219	0.019	266749	266800.687	0.019
10	350	273478	273817.219	0.124	205109	205362.906	0.124
11	363	284346	284502.75	0.055	213259	213377.078	0.055
		Average %Error		0.435	Average %Error		0.426

Table 7. Voltage drop, regulation of voltage drop, and phasor voltage drop data

Bus	Load (kVA)	Voltage (V)	Voltage drop (V)	Voltage drop regulation (%)	Voltage drop phasor (V)
2	745	19913	55	0.276	1.793
3	208	19910	3	0.0151	0.35562
4	496	19869	44	0.2214	2.94366
5	483	19832	37	0.1866	1.441
6	319	19801	31	0.1565	2.3147
7	689	19793	8	0.0404	8.34
8	290	19783	18	0.09098	2.46
9	455	19768	15	0.076	0.6747
10	350	19760	8	0.04047	1.477
11	363	19755	5	0.0253	2.997

4.6. System simulation testing

To configure whether the simulation system working or not, the system will be tested to determine active power (P) and reactive power (Q) on Bendul Merisi Feeder distribution system. The testing will be done by calculating the active power and reactive power value from data received which is voltage and current data every 6 hours, and the role of this simulation is to calculate the active power and reactive power value of each hour from received data. The following Table 8 are voltage and current data that will be tested.

Table 8 contain Voltage and Current also load will be calculated as active power and reactive power value using a designed simulation. The result of the simulation contains calculation results using a simulation that displays active power (P) and reactive power (Q) on each bus of each cluster.

Table 8. Voltage and current data in 8.00–10.00 (GMT+7)

Bus		1			1			1	
		8.00			10.00			13.00	
	kVA	V	I	kVA	V	I	kVA	V	I
2	762	19898	21.9	766	19897	22	770	19896	22.1
3	208	19895	6	209	19895	6	213	19894	6.1
4	539	19845	15.4	541	19844	15.5	545	19843	15.6
5	539	19799	15.4	540	19798	15.4	545	19797	15.6
6	375	19760	10.7	377	19759	10.8	379	19757	10.8
7	834	19750	23.8	836	19748	23.8	842	19746	24
8	349	19736	9.9	353	19734	10.1	355	19733	10.1
9	549	19716	15.6	554	19715	15.8	565	19713	16.1
10	558	19704	15.9	567	19702	16.1	565	19700	16.1
11	458	19698	13	457	19696	13	460	19694	13.1

5. CONCLUSION

From the system designing that has already been done, obtained a few conclusions average results of analysis result difference for active power simulation between calculation with simulation is 0.435%, while for reactive power between calculation with simulation is 0.426%. For average analysis, the result is different from the comparison of ETAP result with simulation result for active power received value of 0.618% while for reactive power 0.556%.

Voltage drops occurred in the distribution line of Bendul Merisi Feeder have a 224 volt total value. Following the PLN voltage standard, voltage drops have a maximum of 10% and at the Bendul Merisi Feeder distribution system, a 20 kV voltage drop recorded with a 1.12% value so the voltage drop is still fulfilled the criteria. At active power and reactive power data retrieval time separated from each bus to 6 hours, where the average power received by all buss minimum is 112137.94 VA at 9.00 AM (GMT+7) and the average power received by all bus maximum is 115129.05 VA at 13.00 (GMT+07).

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