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Analysis of Small Signal Stability of The Interconnected Electrical Power System Between PT.PLN And Rooftop Solar Photovoltaic (Pv) In The Surveyor Laboratory Building, Teuku Umar Street, Samarinda

Ipniansyah[1], Rizky Aprylianto Susilo[2], Rusdiansyah[3],Cornelius Sarri [4]
[1)2)3)4)]Department of Electrical Engineering, State Polytechnic ofSamarinda

ABSTRACT
This research aims to analyze the stability of the small signal interconnection model of the electric power system through the PT.PLN Distribution Network with Rooftopsolar photovoltaic in the Surveyor Laboratory buildings Teuku Umar Street Samarinda according to the required standards. The method used is a Linear Model approach. The results obtained show that the small signal stability analysis applied to the interconnection model of Rooftopsolar photovoltaic with the PT.PLN Distribution Network for frequency and voltage variables shows the ability of the power system to reach a stable condition in new operating conditions that are identical to the conditions before the disturbance occurred. After the system experienced a disturbance small according to the required SPT.PLN D5.005-1: 2015 standards. Stability of Small Signal Interconnection Frequency (Hz) at the 5th minute (5x1389) there was a large decrease in frequency reaching 49.64 Hz or a deviation of 0.36 Hz. Stability of Small Signal Interconnection Voltage (Volt) at the 5th minute (5x1654) there was an increase in voltage reaching 244,710 Volt in the U_1 phase or a deviation of 11.23%. Optimal System Performance on Small Signal Stability Interconnection Voltage (Volt) on day 2 - 06:02:21 to 18:57:21at the 5th minute (5x112) there was a maximum increase in voltage reaching 242.47 Volt or deviation10.21%. System performance on day 2 - 10:02:21 to 16:57:21 in the U_1 phase starting from the 5th minute (5x64) there was a maximum increase in voltage reaching 242.47 Volt or a deviation of 10.21%.

Keyword:*small signal stability analysis, electric power system interconnection model*

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I. INTRODUCTION

Small signal stability, also known as steady-state stability, is the ability of a power system to reach a stable condition under new operating conditions that are the same or identical to the conditions before a disturbance occurs after the system experiences a small disturbance [5]. According to data, the phenomenon of small disturbances has a frequency range between 0 - 2 Hz, where local oscillation modes typically have a frequency range between 1 - 2 Hz, while inter-area oscillation modes have a frequency range below 1 Hz [5,2,8].

Frequency changes that occur over a long period are usually caused by excessive generator loading, and frequency changes that occur only for a short period are often the result of sudden large load additions or releases. As a quality standard, a tolerance of 0.6 Hz is set for frequency deviations from the normal 50 Hz frequency, or the frequency is considered to still be within tolerance if it remains between 49.4 Hz and 50.6 Hz [11].

The interconnection of the Indonesia Power Utility Company or (PT.PLN) power source in the form of a distribution network with the Roof Solar Power Plants also poses challenges for small signal stability, which affects the quality of electricity, especially for users of buildings engaged in specific production and service sectors such as manufacturing industries and testing laboratories.

Small-scale power system interconnection between the PT.PLN power sources and the Roof Solar Power Plants in buildings have a level of utility by the required standards, including the power source, electrical panel, electrical installation, and grounding system.

Small-scale power system interconnection for electricity supply is assumed to consist of the PT.PLN power source in the form of a distribution network with an alternative solar power generator in the form of Roof Solar Power Plants. The utilization of Roof Solar Power Plants is the result of solar energy development, which is part of renewable energy sources for small-scale applications in building categories that are interconnected with the PT.PLN power source, by the Technical Requirements for Photovoltaic (PV) System Interconnection on Low Voltage Distribution Networks based on the required standard SPT.PLN D5 005-1 2015 [10]. This interconnection model is also commonly known as On-Grid Roof Solar Power Plants, although it operates differently concerning anti-islanding protection based on the required standard SNI IEC 62116-2014 [1].

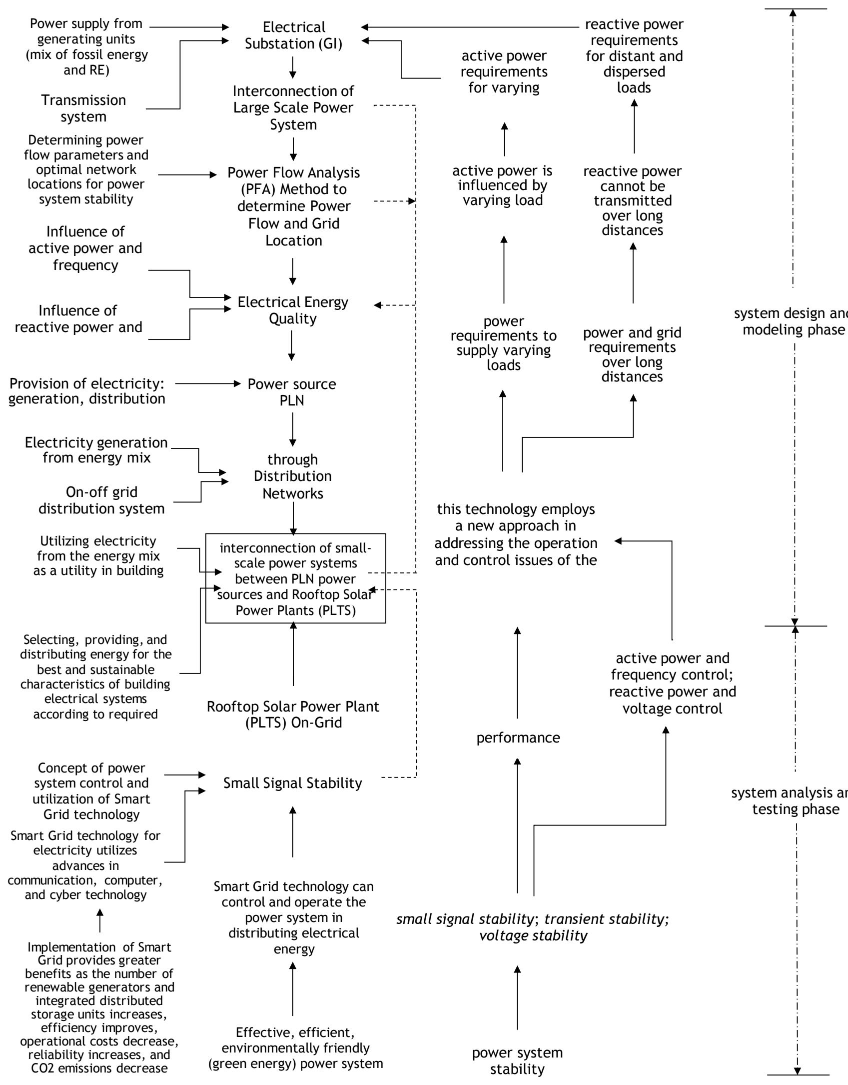
II. RESEARCH METHODOLOGY

Research Framework

The flow of power and grid location, as well as the quality of electrical energy, are significantly influenced by active power and frequency variables, as well as reactive power and voltage variables. The quality of electrical energy in the small-scale electrical power system interconnection between the PT.PLN power source supplied through the Distribution Network and the Rooftop Grid-Connected Solar Power Plant (On-Grid) will be demonstrated as small signal stability, also commonly referred to as steady-state stability.

The conceptual framework related to the targets to be achieved consists of the stages of system design and modeling, and the stages of system analysis and testing. The targets to be achieved in these research process stages are as follows:

1. Stage of system design and modeling, which is a stage to obtain a model of the interconnection system of the small-scale electrical power system between the PT.PLN power source and the Rooftop Grid-Connected Solar Power Plant (On-Grid).
2. Stage of system analysis and testing, which is a stage to obtain an analysis model of small signal stability in the interconnection system of the small-scale electrical power system between the PT.PLN power source and the Rooftop Grid-Connected Solar Power Plant (On-Grid).



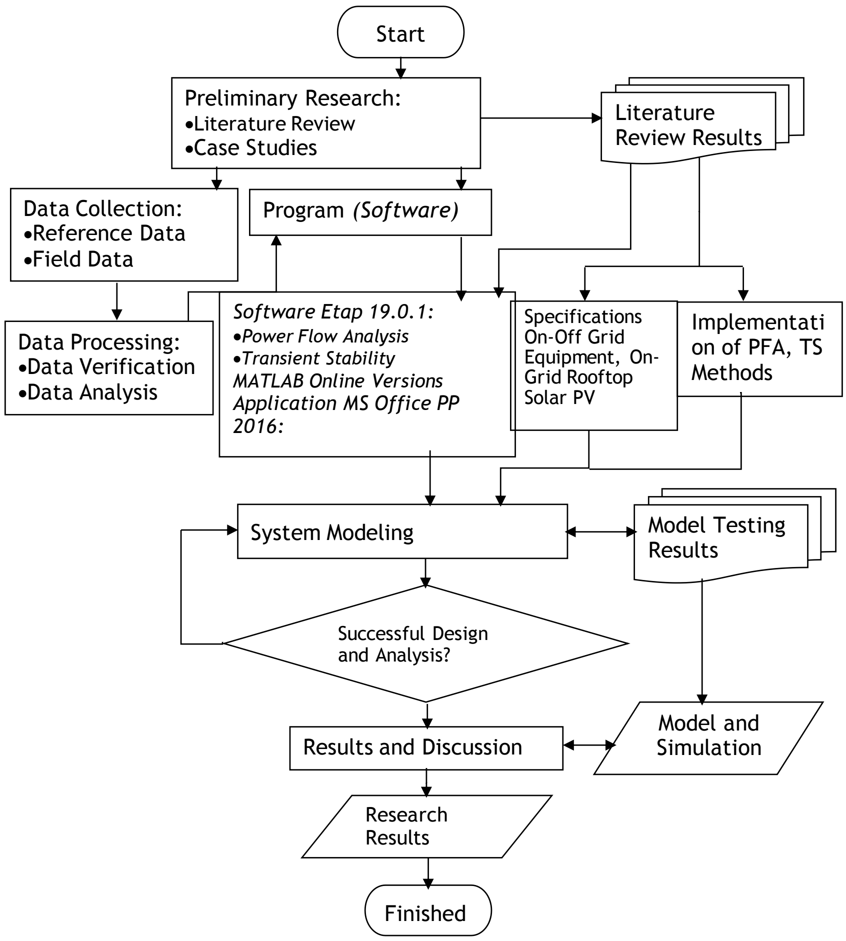
Picture1.Research Framework

Research Operational Framework

The research process begins with preliminary research consisting of a literature review and case studies, followed by data collection in the form of reference data and field data. Reference data includes electrical system data in building structures, covering power sources, electrical panels, electrical installations, and grounding systems, where this reference data is related to the application of Rooftop Grid-Connected Solar Power Plants (On-Grid). Meanwhile, field data consists of interconnection data of the small-scale electrical power system between the PT.PLN power source and the Rooftop Grid-Connected Solar Power Plant (On-Grid) in the building of the Surveyor Laboratory on Teuku Umar Street, Samarinda.

Through deductive and inductive processes, where reference data and field data are verified and analyzed using Software Etap 19.0.1; MATLAB Online Versions; MS Office Professional Plus 2016 Application Software: MS Excel, Data Analysis Tool; resulting in processed data in the form of interconnection data of the small-scale electrical power system between the PT.PLN power source and the Rooftop Grid-Connected Solar Power Plant (On-Grid). The analysis results of this processed data are then further processed to obtain processed data in the form of test results of the model compared to the parameter values of the analysis and system performance by the specified standard limits.

The results and discussions show the research findings in the form of an analysis model of small signal stability (steady-state stability) regarding the interconnection of the small-scale electrical power system between the PT.PLN power source and the Rooftop Grid-Connected Solar Power Plant (On-Grid) in the building of the Surveyor Laboratory on Teuku Umar Street, Samarinda.



Picture2.
Research Operational Framework

III. RESULTS AND DISCUSSION

Determination of the Interconnection Model of Rooftop Solar Power Generation with PT.PLN Distribution Network

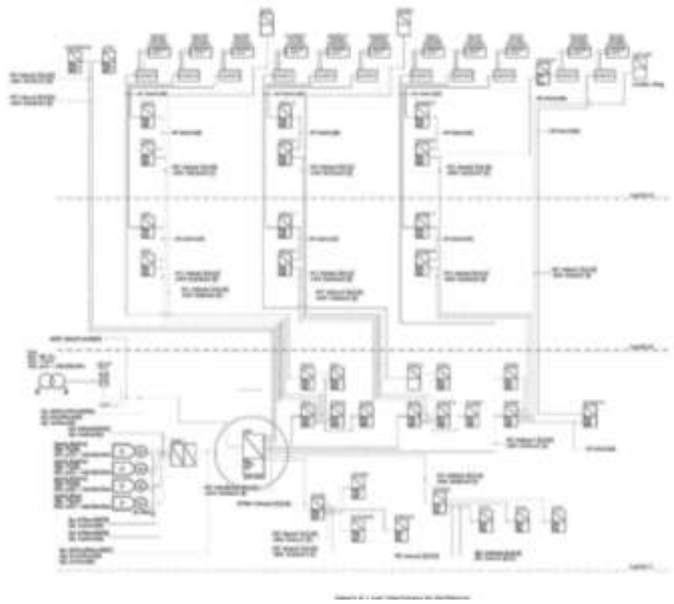
The Interconnection Model of Rooftop Solar Power Generation with PT.PLN Distribution Network in this context is a model of a small-scale electrical power system interconnection between PT.PLN electricity source and Rooftop PV. It can also be referred to as an interconnection model or a parallel connection of a small-scale electrical power system between PT.PLN electricity source through the Distribution Network with the Solar Power Generation On Grid at the Laboratory Building on Teuku Umar Street, Samarinda. This is achieved using Qualitative-Descriptive Analysis and Quantitative Descriptive Analysis methods, resulting in:

a. The level of utility of the electrical system complies with the required standards, including the power source, electrical panel, electrical installation, and grounding system.
b. Standard requirements in the form of the same variable quantities, including phase sequence polarity, voltage, and frequency.

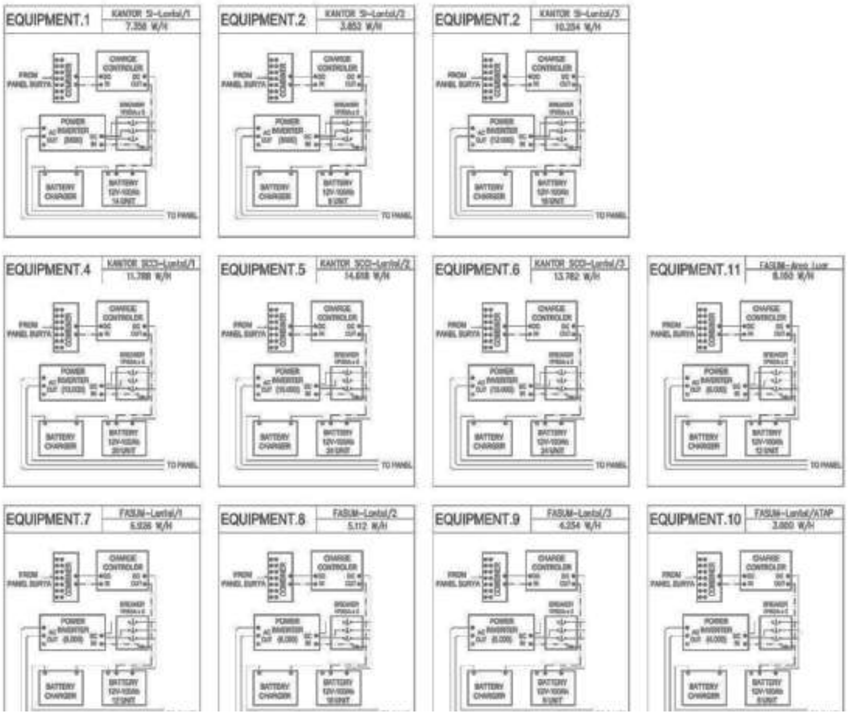
Determination of the Rooftop Solar Power Generation Model

The Rooftop Solar Power Generation Model at the Laboratory Building on Teuku Umar Street, Samarinda, is determined based on categories using Qualitative-Descriptive Analysis and Quantitative Descriptive Analysis methods, resulting in:

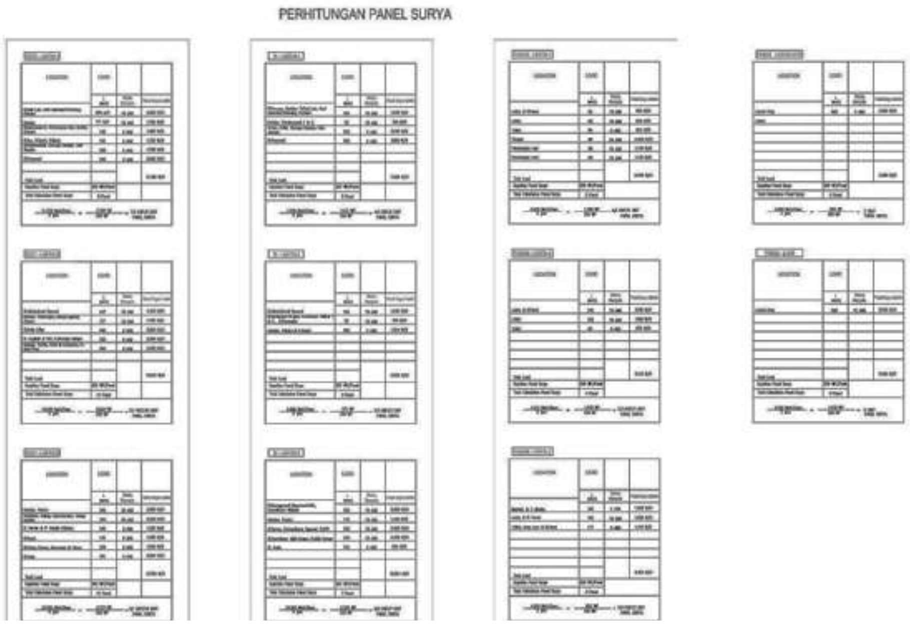
1. Type of PV based on System: On-Grid PV, which is a PV system connected to the PT.PLN network and under certain conditions can function as a Hybrid PV, which is a PV system that uses a combination of solar energy with other energy sources such as diesel generators (Genset). Hybrid PV combines the advantages of On-Grid and Off-Grid systems, meaning it can be connected to the PT.PLN network also operates independently when the electricity supply from PT.PLN is down.
2. Type of PV based on Distribution Network: Scattered PV, which is a generator that does not have a distribution network and is used only for its own needs, independently built-in buildings/houses without being connected. Types of PV based on distribution networks can be combined with On-Grid, Off-Grid, and Hybrid PV systems.
3. Type of PV based on Installation Location: Rooftop PV, which is a power generator that installs solar panels on the roof of a building to save electricity consumption from the PT.PLN network. PV is categorized according to the installation location to suit the needs. Installing solar panels requires strong and environmentally safe structural support.



Picture3.
Electricity Sources in Rooftop PV Models Based on Distribution Systems and Networks



Picture4.
Solar Panel System on Rooftop PV Model based on Distribution System and Network



Picture5.
Calculation of Solar Panels on Rooftop PV Models based on Distribution Systems and Networks

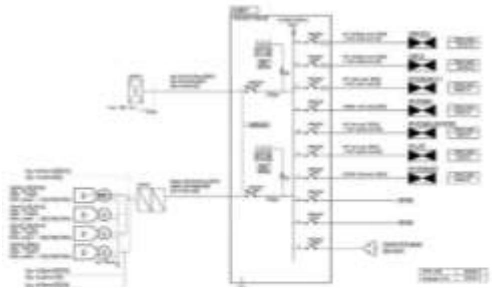
Determining the Interconnection Model for Rooftop PV with the PT.PLN Distribution Network

The interconnection model of the Rooftop Solar Power Systemwith the Teuku Umar Road Surveyor Laboratory building's PT.PLN Distribution Network is determined based on the following requirements, using the methods of Qualitative-Descriptive Analysis and Descriptive Quantitative Analysis:

1. The PV system, which is connected to the network, continuously varies the flow of electricity from the solar module array. This must be converted by an inverter into an alternating current with a frequency of 50 Hz. Therefore, an inverter with high safety and efficiency characteristics is required.
2. The inverter for the interconnected PV system must be equipped with various circuit control parameters that can operate with the existing network voltage and force the grid to accept power from the PV. The

inverter must be able to function as a current source and also be equipped with an automatic anti-islanding control circuit.

3. The PV system can act as an emergency backup during power outages, but it remains connected to the PT.PLN network. This allows for the maximization of electricity utilization from the PV Hybrid solar panels.
4. The hybrid PV scheme operates with the existing electrical system but is also equipped with batteries as a storage medium. This allows the PV to continue running in case of a power outage in the existing electricity supply.



Picture6.
Electrical Panels on Rooftop PV Models based on Distribution Systems and Networks

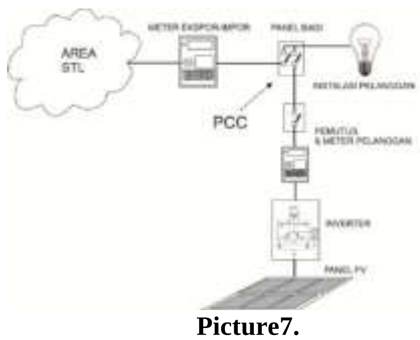
Determining the Operation Model for Rooftop PV Interconnection with the PT.PLN Distribution Network

The operational requirements and interconnection are based on the SPT.PLN D5.005-1: 2015 standard regarding Technical Requirements for Photovoltaic (PV) System Interconnection to Low Voltage Distribution Network (JTR) consists of operational requirements and interconnection requirements. Operational requirements include parallel operation mechanisms and conditions, as well as post-parallel islanding protection. Meanwhile, interconnection requirements encompass interconnection parameters and photovoltaic system protection to JTR, other protections in the PV system, and grounding integration.

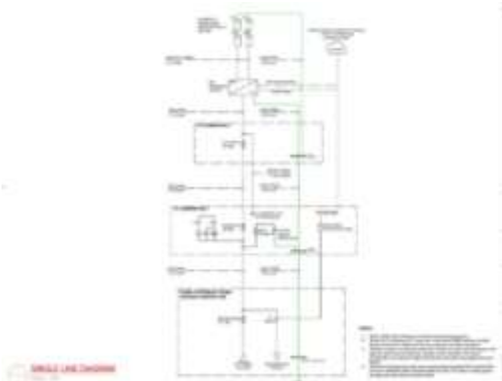
The Operation System Model for Photovoltaic (PV) System Interconnection to Low Voltage Distribution Network is based on the operational layout of the photovoltaic (PV) system to the PT.PLN Low Voltage Distribution Network. The Operation System Model for a 22 kWp Rooftop Solar Power Plant with PT.PLN Distribution Network at the Architectural Building of Samarinda State Polytechnic.

Stability of Small Signal Electric Power System Interconnection Model of Rooftop PV with PT.PLN Distribution Network

Analysis of the stability of the small signal electrical power system interconnecting the Rooftop PV with the PT.PLN distribution network in the Surveyor Laboratory building on Teuku Umar Street, Samarinda was carried out on the Rooftop PV system which was connected in parallel by the interconnection and operation requirements.



Picture7.
Operating System for Photovoltaic (PV) System Interconnection Model on Low Voltage Distribution Network based on Photovoltaic System (PV) Operation Layout to PT.PLN's Low Voltage Distribution Network



Picture8.
Interconnection Model Operation System of 22 kWp Rooftop Photovoltaic System with PT.PLN Distribution Network at the Architecture Building of Samarinda State Polytechnic

Operating Mechanism in the Rooftop PV Interconnection Model with the PT.PLN Distribution Network

Synchronization and parallel installation of PV customer and JTR area are automatically performed by the inverter using a parallel mechanism, which involves:

1. Checking if the system can detect the JTR area voltage.
2. Adjusting the output voltage, such as parameters for frequency difference, voltage difference, and phase angle difference according to Table 1.
3. Verifying if the Rooftop Solar Power Plant (PV Atap) system has been paralleled with the customer's electricity supply from the PT.PLN JTR.
4. Verifying that after parallel operation, voltage fluctuations at the Point of Common Coupling (PCC) must not exceed 5% of the promised PCC voltage in the Service Quality Level (Tingkat Mutu Pelayanan - TMP).

After the parallel or post-parallel (anti-islanding protection) PV system is connected to the JTR area, if an abnormal situation occurs, the PV system must be able to detect and respond according to the provisions, namely:

Table1.
Parallel Installation Requirements

PV Aggregate Power Limit (kVA)	Frequency Difference Δf (Hz)	Voltage Difference ΔV/V (%)	Phase Angle Difference ΔØF (°)
0-200	0,3	10	20

1. Check that PV customer installations must be automatically disconnected from the JTR area if power from JTR is cut off either due to disturbances or planned outages for construction work, maintenance, or other activities. Automatic release is carried out by the inverter and/or energy meter (export-import meter)
2. check the detection of abnormal conditions when the system voltage and frequency differ outside the values in Table 2 and Table 3, then the connection to the JTR area must be removed automatically within a certain time
3. Check the clearing time due to voltage deviations and frequency deviations according to Table 2, Table 3, and Table 4. After the JTR area returns to normal, the inverter or transaction meter must be able to detect and be able to close/reconnect the JTR area with the customer installation side (PV) by giving commands to the main switch/share switchboard (PHB) at the Point of Common Coupling (PCC) or by the meter itself. The re-closing time requirement is not less than 300 seconds.

Table2.
Post-parallel Eligibility and release time

Condition Voltage (% nominal)	Inverter Maximum Discharge Time (seconds)	Energy Meter Minimum Discharge Time (seconds)*)
$V < 50$	0,16	0,46
$50 \leq V < 88$	2,0	2,3
$88 \leq V \leq 110$	Operation	Operation
$110 < V < 120$	1,0	1,3
$V \geq 120$	0,16	0,46

Table3.
Compliance Frequency and timing of releases

Aggregate PV Power (kWp) Limitations	Frequency (Hz)	Inverter Maximum Discharge Time (seconds)	Energy Meter Minimum Discharge Time (seconds)*)
≤ 30	> 50,4	0,16	0,46
	< 49,4	0,16	0,46

Table4.
Compliance Maximum harmonic current and voltage distortion

Harmonic Individual Order (H)	h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h ≤ 35	h > 35	THD (current)	THD (voltage)
%	4,0	2,0	1,5	0,6	0,3	5,0	3,0

The interconnection parameters (after paralleling) of the customer's photovoltaic system to JTR include voltage, frequency, harmonics, power factor (pf), voltage flicker, and direct current (DC) injection, namely:

a. Voltage: when the system voltage is far from the nominal value of the connection to the JTR area, it must be removed automatically within a certain time. The complete clearing time is according to the limitations of Table 2.
b. Frequency: the existence of operational constraints that cause changes in frequency to its nominal value on the JTR must be able to be responded to by the customer installation (PV) by removing the PV system from the JTR. Release time according to Table 3.
c. Harmonics: the harmonic distortion threshold of the current and voltage generated by PV to the JTR area, both total harmonics and each permitted order, must be by Table 4.
d. Power factor: minimum PV operating power factor 0.9 lagging.
e. Voltage flicker: the PV system must not cause flicker interference to other customers connected to the JTR area. Voltage flicker requirements according to point 8.2 SPT.PLN D5.004-1: 2012.
f. Direct current (DC) injection: direct current injection of the PV system must not exceed 0.5% of the nominal current carrying capacity of the service inlet (SMP) or the capacity of the PV system, whichever is smaller.

Small Signal Stability Analysis of the Electric Power System Interconnecting Rooftop PV with the PT.PLN Distribution Network

In the context of the stability of the small signal electrical power system interconnecting the Rooftop PV with the PT.PLN distribution network in the Surveyor Laboratory building on Teuku Umar Street, Samarinda, the small signal stability analysis is carried out on the Rooftop PV system which is connected in parallel by the interconnection and operation requirements as described in on. Apart from paying attention to the capacity of the Rooftop PV, you also pay attention to the peak load during the day. This peak load value is obtained by multiplying the number of devices and the power per load device used together during the day.

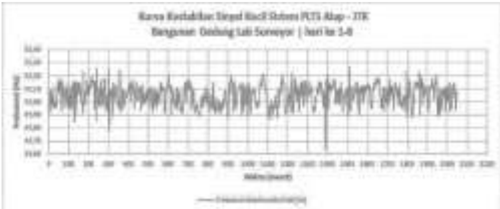
The power produced by PV Rooftops will reduce the power consumed by the PT.PLN network. Rooftop PV energy savings, assuming that the load curve is constant, the efficiency savings that occur are shown in the shaded area. Thus, this curve area is used as a boundary area for the stability of small signals for the interconnection of the PV Rooftop electricity system with the PT.PLN distribution network in the Surveyor Laboratory building on Jalan Teuku Umar, Samarinda.

Picture9.

Small Signal Stability Area Limitations Electric Power System Interconnection of Rooftop PV with PT.PLN Distribution Network in Surveyor Laboratory Building Teuku Umar Street, Samarinda

Small signal stability (small signal stability) of a small-scale interconnection electric power system between the PT.PLN power source and PV. The roof of the Surveyor Laboratory building on Teuku Umar Street, Samarinda has the ability of the power system to reach stable conditions under new operating conditions that are identical to the previous conditions. A disturbance occurs after the system experiences a small disturbance using the Linear Model approach and the Qualitative-Descriptive Analysis and Quantitative-Descriptive Analysis methods which are processed based on reference data.

The stability of the small signal stability of the small-scale interconnection electric power system between the PT.PLN power source and the Rooftop PV on the Surveyor Laboratory building on Teuku Umar Street, Samarinda can be seen through the frequency and voltage variables when the Rooftop PV operates in an 8 (eight) cycle period. days or up to (5x2048) minutes starting from 13:02:21 to 15:41:13 based on observations at the main switch point/share switchboard (PHB) at the Point of Common Coupling (PCC)/Energy Meter DTSD1352 -C/1 (6A) PV Rooftop - JTR, with variable data: Time (hours), Interconnection Frequency f±Δf (Hz), and Interconnection Voltage V±ΔV (V).



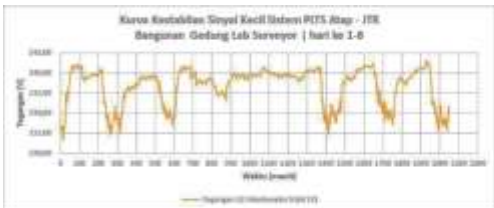
Picture10.

Small Signal Stability Curve Interconnection Frequency (Hz) Small Scale Interconnection Electric Power System Rooftop PV with PT.PLN JTR in Surveyor Laboratory Building Jalan Teuku Umar Samarinda

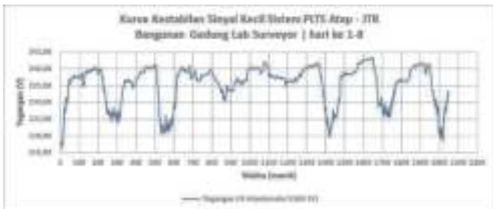
Small Signal Stability Curve Interconnection Frequency (Hz) of the Small Scale Interconnection Electric Power System Rooftop PV with the PT.PLN Distribution Network in the Surveyor Laboratory Building Teuku Umar Street, Samarinda shows that at the 5th minute (5x1389) there was a large decrease in frequency reaching 49.64 Hz or a deviation of 0.36 Hz. Meanwhile, in the 5th minute (5x1510), the frequency increased to 50.27 Hz or a deviation of 0.27 Hz.

(a).Phase U_1-U_2-U_3

(b).Phase U_1



(c).Phase U_2



(d).Phase U_3

Picture11.

Small Signal Stability Curve Interconnection Voltage (Volts) Small Scale Interconnection Electric Power System Rooftop PV with PT.PLN JTR in Surveyor Laboratory Building Teuku Umar Street, Samarinda

Small Signal Stability Curve for Interconnection Voltage (Volts) for the Small Scale Interconnection Electric Power System Rooftop PV with the PT.PLN Distribution Network in the Surveyor Laboratory Building on Teuku Umar Street, Samarinda shows that at the 5th minute (5x1389) there was a large decrease in voltage reaching 216,370 Volts in the U3 phase or there is a deviation of up to 1.65%. Meanwhile, in the 5th minute (5x1654) there was an increase in voltage reaching 244,710 Volts in the U1 phase or a deviation of 11.23%.

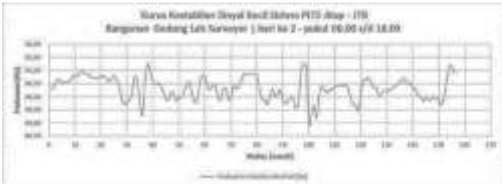
Optimal System Performance for Small Signal Stability of Electric Power Interconnecting Rooftop PV with the PT.PLN Distribution Network

The performance of the interconnection electric power system of Rooftop PV with the PT.PLN distribution network shows the level of performance of the system that has installed interconnection devices or parallel connections between PT.PLN electricity sources via the Distribution Network and On-Grid Rooftop PV in the Surveyor Laboratory building on Teuku Umar Street, Samarinda.

System performance is measured and displayed according to the same variable quantities including phase sequence polarity, voltage, and frequency. Optimal small signal stability (steady state stability) is a function of operating conditions to increase or decrease frequency and voltage within certain limits, namely by using the Linear Model approach and methods of Statistical Analysis - Descriptive, Qualitative Analysis - Descriptive, and Quantitative Descriptive Analysis. processed based on reference data.

Analysis of the Performance of the Electric Power System Interconnecting Rooftop PV with the Low Voltage Network. PT.PLN emphasizes or prioritizes optimal system performance on Small Signal Stability. Electric Power System Interconnecting PV Electricity Sources with Rooftop PV on Surveyor Laboratory Buildings Teuku Umar Street, Samarinda during operation in the 8 (eight) cycle period.) days or for (5x2048) minutes starting from 13:02:21 to 15:41:13 based on observations at the main switch point/share switchboard (PHB) at the Point of Common Coupling (PCC)/Energy Meter DTSD1352 -C/1 (6A) PV Rooftop - JTR, with variable data: Time (hours), Interconnection Frequency f±Δf (Hz), and Interconnection Voltage V±ΔV (V).

Optimal system performance curve for small signal stability during operation within a 13 (thirteen) hour cycle period starting at 06:02:21 to 18:57:21 and a 7-hour cycle period starting at 10:02:21 s /d at 16:57:21.



(a).

2nd day - 06.00 to 18.00

(b).

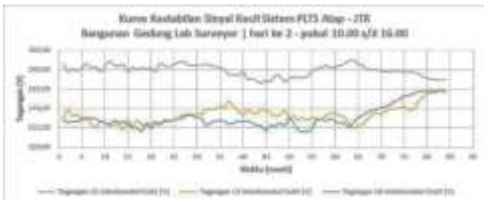
2nd day - 10.00 to 16.00

Picture12.
Optimal System Performance Curve for Small Signal Stability Interconnection Frequency (Hz) Small Scale Interconnection Electric Power System Rooftop PV with PT.PLN Distribution Network in Road Surveyor Laboratory Building Teuku Umar Street, Samarinda

Optimal System Performance Curve for Small Signal Stability Interconnection Frequency (Hz) of Small Scale Interconnection Electric Power System Rooftop PV with JTR PT.PLN in the Surveyor Laboratory Building Teuku Umar Street, Samarinda shows that on day 2 - 06:02:21 to 18:57:21 starting at the 5th minute (5x100), there was a large decrease in frequency reaching 49.78 Hz or a deviation of 0.22 Hz. Meanwhile, in the 5th minute (5x38) there was an increase in frequency reaching 50.25 Hz or a deviation of 0.25 Hz.

System performance can also be seen on day 2 - from 10:02:21 to 16:57:21, starting from the 5th minute (5x52), there was a large decrease in frequency reaching 49.78 Hz or a deviation of 0.22 Hz. Meanwhile, in the 5th minute (5x50), the frequency increased to 50.25 Hz or there was a deviation of 0.25 Hz.

(a).
Phase U1-U2-U3 | 2nd day - 06.00 to 18.00



(b).
Fase U_1-U_2-U_3 | hari ke 2 - pukul 10.00 s/d 16.00
Picture13.
Optimal System Performance Curve for Small Signal Stability Interconnection Frequency (Hz) Small Scale Interconnection Electric Power System Rooftop PV with PT.PLN JTR in Road Surveyor Laboratory BuildingTeuku Umar Street, Samarinda

Optimal System Performance Curve for Small Signal Stability Interconnection Voltage (Volts) of Small Scale Interconnection Electric Power System Rooftop PV with PT.PLN JTR in the Surveyor Laboratory Building Teuku Umar Street, Samarinda shows that on day 2 - 06:02:21 to 18:57:21 in the U3 phase starting from the (5x102) minute, there was a minimum increase in voltage reaching 223.98 Volts or a deviation of 1.81%, and in the (5x13) minute there was a maximum increase in voltage reaching 240.10 Volts or deviation of 9.14%.

Meanwhile, on day 2 - from 06:02:21 to 18:57:21 in the U1 phase starting from the 5th minute (5x92) there was a maximum increase in voltage reaching 236.62 Volts or a deviation of 7.55%, and in the second (5x112) there was a maximum increase in voltage reaching 242.47 Volts or a deviation of 10.21%.

System performance can also be seen on day 2 - from 10:02:21 to 16:57:21 in the U3 phase starting from the 5th minute (5x53) there was a maximum increase in voltage reaching 223.98 Volts or a deviation of 1.81%, and in the 5th minute (5x83) there was a maximum increase in voltage reaching 234.65 Volts or a deviation of 6.66%.

Meanwhile, on day 2 - from 10:02:21 to 16:57:21 in the U1 phase starting from the 5th minute (5x44) there was a maximum increase in voltage reaching 236.62 Volts or a deviation of 7.55%, and in the second (5x64) there was a maximum increase in voltage reaching 242.47 Volts or a deviation of 10.21%.

IV. CONCLUSION

1. Small signal stability analysis applied to the Rooftop PV interconnection model with the PT.PLN Distribution Network in the Surveyor Laboratory building on Teuku Umar Street, Samarinda for frequency and voltage variables shows the ability of the power system to reach a stable condition under new operating conditions that are identical to the conditions before a disturbance occurs after the system experiences a minor disturbance according to the required SPT.PLN D5.005-1: 2015 standard
2. Small Signal Stability Interconnection Frequency (Hz) at the 5th minute (5x1389) there was a large decrease in frequency reaching 49.64 Hz or a deviation of 0.36 Hz. Stability of Small Signal Interconnection Voltage (Volts) at the 5th minute (5x1654) There was an increase in voltage reaching 244,710 Volts in the U1 phase or a deviation of 11.23%. Optimal System Performance on Small Signal Stability Interconnection Voltage (Volts) on day 2 - at 06:02:21 to 18:57:21 at the 5th minute (5x112) there was a maximum increase in voltage reaching 242.47 Volts or occurred deviation 10.21%. System performance on day 2 - 10:02:21 to 16:57:21 in the U1 phase starting from the 5th minute (5x64) there was a maximum increase in voltage reaching 242.47 Volts or a deviation of 10.21%.

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