

POWER QUALITY ANALYSIS AT BUILDING OF POLITEKNIK NEGERI AMBON

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ABSTRACT

Power quality determines the reliability of electrical energy transmission which reflects the parameters of voltage, frequency, frequency, balance, and waveform. Electrical quality in a building is required due to abnormal effects on current, voltage, and frequency. By measuring it can be seen whether or not the abnormal electrical quality in the Ambon State Polytechnic's electrical system. The method used is data collection through literature study and observation of research locations, as well as descriptive analysis with a statistical approach. The Ambon State Polytechnic receives electricity from a power plant with a three-phase wire system. The load is supplied by a 3-phase transformer 20 kV/380 V With a power capacity of 250 kVA. carried out using a Power Analyzer where the tool for one day (24 hours) records electrical data for Polnam testing. Through tabulation and data analysis, there are several facts that there are abnormal conditions both in voltage, current, and frequency because the magnitude is outside the set standard. The results of the recommendation of the need for interference estimation begin with the selection of the right method.

Keywords: Power quality, current fault, voltage fault, harmonics

INTRODUCTION

PolicyElectrical energy is one of the basic needs that humans need both in industry, offices and the use of other electrical equipment. Indonesia's electrification ratio in 2020 reached 99.2%, which exceeded the Ministry of Energy and Mineral Resources' RPJM target of 97.5% in 2019 (Tasrif, 2020). This shows that most Indonesians have enjoyed the benefits of electricity. The utilisation of electrical energy has reached various sectors of life ranging from households to commercial needs, especially government and industrial agencies (Mulyani & Hartono, 2018).

The need for electrical energy that continues to grow demands a continuity of electrical power supply with appropriate power quality (Manjang et al., 2014). However, this cannot be guaranteed because not all electrical loads used are linear. Most of the electrical equipment used in industry as well as commercial and office buildings are electronic equipment and electric motors which are nonlinear loads (Mulia, 2017). Nonlinear loads have a negative effect on the quality and continuity of electrical energy distribution. This is indicated by the disturbances caused both in voltage, current, frequency, and balance in the three-phase power supply (Syahputra et al., 2018).

Power quality determines the reliability of electrical power flow that describes the characteristics of voltage, current, frequency, balance, and waveform parameters (Faruq et al., 2021). Good electrical power quality makes the life of electrical equipment longer. The importance of electrical power quality, so that its existence gets attention both on the source side and on the user side. Monitoring the quality of electrical power in a building is necessary because of the abnormal influence of the use of installed electronic loads on current, voltage, and frequency parameters (Kusnadi & Aji, 2016). As a result, electronic equipment is easily damaged, equipment operation fails, and another disadvantage is the increase in electricity

bills.

Politeknik Negeri Ambon is a building with educational and commercial facilities (offices) where there are a number of equipment installed to support academic activities, such as electronic equipment (computers, printers, projectors, etc.), and a large number of practical equipment in laboratories and workshops. These equipment are nonlinear in nature which can adversely affect the power quality as mentioned in the previous explanation. The effect of poor electrical power quality is also experienced at Ambon State Polytechnic, one of which is frequent interruptions or blackouts in workshops and laboratories due to the failure of practical equipment. As a result, the service life of the equipment decreases because it often operates at a level that is not in accordance with standard specifications. Based on this background, research will be conducted in the form of measurement and analysis of the quality of electrical power in electrical installations at the Ambon State Polytechnic. Through measurement we can find out whether there is an abnormal condition of electric power quality. If there are power quality problems, the researcher will recommend solutions that can be implemented in the electricity system at the Ambon State Polytechnic..

METHODS

Some categories of this type of research are explained as follows, based on its use, this research is applied research because it solves practical problems related to the electricity field, namely the problem of electric power quality. Based on the method, this research is evaluation research because the research results based on data processing are used to support decision making. Based on the type of data and analysis, this research is a combination of kuliitatif and quantitative research. Based on the nature of the problem, this type of research is field research.

Research activities are related to data because data is needed as raw material that will be processed and used to solve problems or test hypotheses based on a model. Based on the data source, the data used in this research are primary data and secondary data. Primary data is obtained through direct observation in the field and its management which is further supported by secondary data through books or journals. Data based on its nature is a combination of quantitative and qualitative data. Quantitative data is in the form of numbers and is processed using mathematical techniques.

Meanwhile, qualitative data is obtained when the analysis is carried out. Data based on collection time is periodic data where data collection is carried out periodically. Primary data to be processed is sample data taken periodically (at certain scheduled times), namely data on current, voltage, frequency, harmonics, power loss, power factor, and load balance. There are two methods of collecting research data, namely: (1). Literature Study. Literature study is needed in order to search for literature related to previous research and theories related to research to meet secondary data needs, (2). Observation. This type of research is field research so that it requires observation of the research location to determine the data collection point so that primary data needs are met. In addition, through the observation method, researchers make regular observations through measurements made several times.

The analysis method used in this research is descriptive analysis. The measurement data were collected and then the data results were described through a statistical approach. Furthermore, comparative analysis is carried out, namely comparing these results with PLN standards or international standards such as IEC, NEMA, or IEEE. This research consists of dependent variables and independent variables which can be explained as follows:

1. The dependent variable

The dependent variable in this study is the quality of power that shows the good or bad

quality of electrical power due to disturbances that occur in the electricity system. The poor quality of electrical power will affect the damage to equipment that is sensitive to changes in current, voltage, and frequency.

2. Independent variable

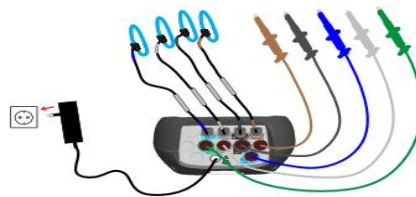
The independent variable in this study is the design and design of an electrical power quality improvement system.

DISCUSSION

Testing

The first step in carrying out this research is to study the function and work of the power analyser measuring instrument. This power analyser measuring instrument is the production of METREL MI 2892 series including new tools in the Electrical Engineering Department laboratory and has never been used in data collection. Therefore, researchers need time to understand the function of each menu provided, how to use and set up, and installation to the network. After learning the functions and workings of the tool, researchers then tested the tool where the tool for one day (24 hours) recorded POLNAM electrical data. The researcher conducted the test directly at the research location, namely at the main panel (MDP) of POLNAM.

The work step of installing the power analyser is to install current and voltage sensors consisting of 4 clamp cables to measure current, and 4 jumper cables to measure voltage. The cables are installed according to the phase order of R, S, T, and Neutral. The phase sequence for current is I1, I2, I3, and IN, and for voltage is L1, L2, L3, and N. This phase sequence is adjusted according to the label and colour of the cable.



Installation of current and voltage sensors on measuring instruments

Next is to install clamp and jumper cables on the three-phase four-wire cable in the main panel following the phase sequence corresponding to the phase colour on the panel cable (R, S, T, and Neutral) by first turning off the power supply and removing the load.



Figure 3. (a) Installation of clamp and jumper (b) Clamp and jumper attached to phase, neutral and ground wires

Once installed, the power supply is re-enabled and the load is inserted, the next step is to set up the tool. Some of the instruments that are set include the date of data collection, record interval, and recording duration. The initial experiment was carried out with a record interval of 10 seconds (second) with a duration of 1 day (24 hours).



Figure 4: Setting the measuring instrument

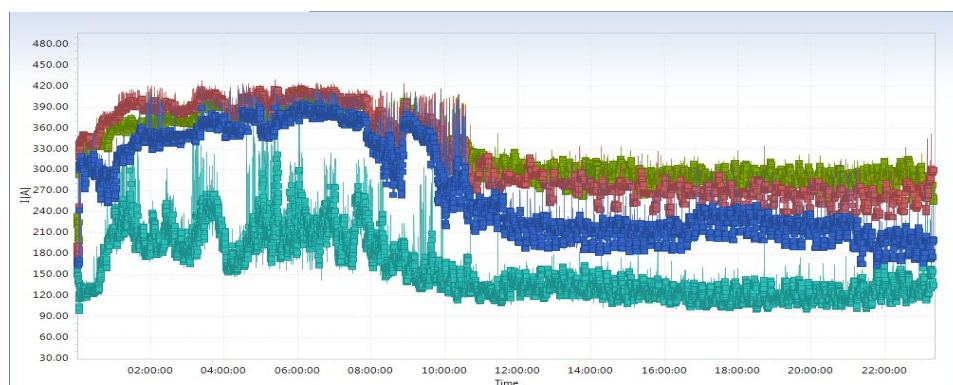
The equipment was left for one day to record the electrical phenomena of current, voltage, power and frequency at POLNAM, and the next day the data was taken for analysis. At the time of data collection, the device was removed with the same procedure as during installation, i.e. the power supply was switched off first before the clamp and jumper removal work was carried out. Next is the process of transferring data from the measuring instrument to the computer for further analysis. After the test was carried out, then for one week on working days, researchers recorded data in the same way and then analysed the electrical phenomenon or power quality in the Ambon State Polytechnic building.

Testing Results

Time: 08.00 WIT (09/10/2020) - 08.00 WIT (10/10/2020). Interval: 10 seconds

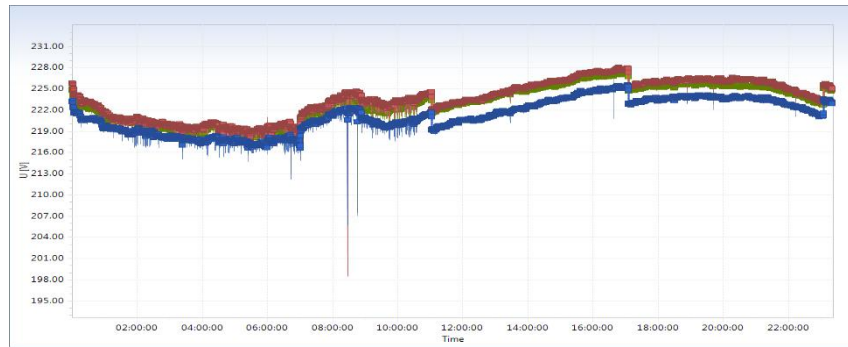
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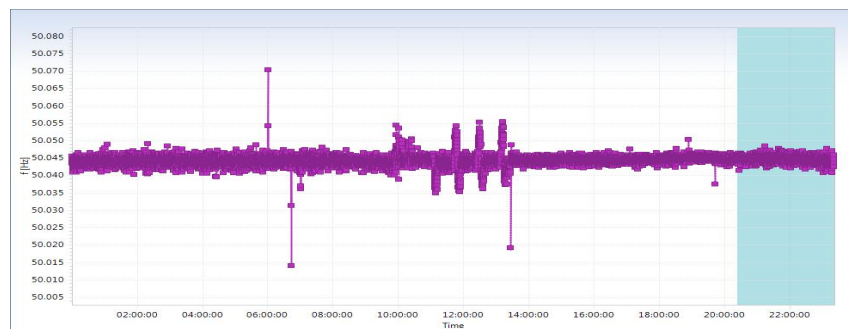
Peak load time	09.04 - 17.49 WIT
Max Current	$I_1 = 355.16 \text{ A}$, $I_2 = 388.25$, $I_3 = 376.94$
Neutral Current	$I_N = 198.65 \text{ A}$

Current curve and current measurement data



Minimum voltage Duration	10.05 - 15.03 WIT (5 jam)
Minimum voltage	$U_1 = 217.84 \text{ V}$, $U_2 = 219.59 \text{ V}$, $U_3 = 219.12 \text{ V}$
Average voltage	$U_1 = 221.19 \text{ V}$, $U_2 = 223.51 \text{ V}$, $U_3 = 222.97 \text{ V}$

Voltage curve and voltage measurement data



Average frequency	50.04 Hz
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Frequency curve and frequency measurement data

Discussion

Data was taken for 4 days starting from 13 October 2020 to 16 October 2020. Data is taken for 12 hours. Based on the tabulated measurement data, the values of voltage, current, power, and frequency can be evaluated whether these values are within the operational standards required in electrical installations.

Voltage disturbance

Under voltage

The results of voltage data tabulation show the presentation of under voltage values as follows:

Table 1. Measurement data of under voltage

Under voltage	Day I	Day II	Day III	Day IV	Rata-rata
U1	0.66%	1.27%	1.02%	1.33%	1.07%
U2	0.08%	0.4%	0.31%	0.58%	0.34%
U3	0.07%	0.4%	0.5%	0.8%	0.44%

The IEEE 1159-1995 standard states that the voltage is declared under (under voltage) if the duration of time there is a decrease of more than 1 minute with a voltage below 90% or it can be said that the allowable voltage drop is 10% of the nominal voltage (Rais, 2020). Based on the data in Table 1, the voltage drop presentation is still within the allowable time limit.

Voltage Dip/Sag

The measurement results also show the occurrence of other voltage disturbances, namely voltage dip/sag occurring on the first day, third day, and fourth day. During data collection it turns out that almost every day the system experiences voltage dip interference.

Table 2. Voltage dip measurement data

DAY	DURATION	FASA	FASA VOLTAGE	VOLTAGE DIP
I	00:00.2	L3	197.921	10%
III	00:01.0	L1, L2, L3	125.369	43%
	00:00.4	L1	194.1286	11.7%
IV	00:00.0	L2, L3	166.2206	24.4%

Measurement results 4.2. The measurement results show that the voltage dip phenomenon occurs in reference to the IEEE 1159-1995 standard which shows that the disturbances that occur on the first and third days are momentary because the duration of the disturbance is between 30 cycles (1 cycle 0.02 seconds) to 3 seconds. While the disturbance on the fourth day is instantaneous because the duration is very short, which is less than 0.5 cycle. The phenomenon of short-duration voltage disturbances with significant voltage drops is caused by the starting of high-powered motors. This can happen because the POLNAM environment is faced with the operation of laboratory and workshop equipment which is of course installed with this equipment. The starting of these large motors generally absorbs 5-6 times the rating current which affects the system voltage.

To overcome this situation, it is better to avoid using Direct Online (DOL) or Star delta starting methods in operating electric motors. It is better if the wiring used for starting the motor uses an auto transformer, soft starter, or Variable Speed Drive (VSD).

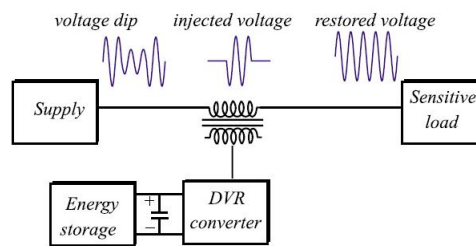
Flicker

Another voltage disturbance recorded on the METREL MI 2892 measuring instrument is flicker. Flicker or known as voltage flicker can be observed from the brightness of the lamp changing intermittently. The data shows that the short-term flicker Pst (observation in 10-minute intervals) has exceeded the limit value of 1.0 and the long-term flicker Plt (observation in 2-hour intervals) has exceeded the limit value of 0.65 (IEC 61000-3-3 standard).

The cause of frequent flicker at POLNAM is due to the use of loads such as the use of arc equipment (electric welding) which is commonly found in engineering workshops, the use of electronic equipment which is a nonlinear load in laboratories and offices, or the potential for coslets on intersecting cables.

Voltage improvement to a nominal value that is always constant and continuous even when faced with load characteristics that cause voltage disturbances such as voltage dip and flicker as mentioned above can use compensation methods in the form of installing special power devices (costume power). The most suitable costume power device in overcoming voltage problems is the Dynamic Voltage Restorer (DVR).

DVR has a performance based on the controller to detect the dip voltage that occurs to compensate for the load voltage (Suryo et al., 2020). The controller must have a fast and accurate response, so that it can compensate the load voltage. The controller regulates how much compensation voltage is needed when dip voltage occurs.



Use of DVR to correct voltage

Current Disturbance

Three phase unbalance

The electrical installation system installed at POLNAM is of the 3 phase 4 wire type. The limitation of this system is that it cannot be guaranteed that the current in each phase is balanced because most of the loads at POLNAM are single-phase loads. As a result, based on the measurement results, there is a current flowing in the neutral wire with a significant value shown in table 4.3.

Table 3. Neutral current measurement

Neutral Current(A)				
Day I	Day II	Day III	Day IV	Average
177.68	214.09	198.89	216.58	201.81

The presence of neutral current will cause power loss or losses in the system due to the flow of neutral current to the ground. This will reduce the efficiency of the transformer. The flow of high neutral currents is caused by an imbalance in the load current in the three-phase system. The amount of unbalanced three-phase current can be seen in the unbalance current curve with the % balance of three-phase current can be calculated as follows based on NEMA MG 1 standard calculations.

Table 4. percentage of three-phase current unbalance

Measurement Time	I_R	I_S	I_T	I Average	a	b	c	% unbalance
Day I	389.13 A	503.46 A	484.65 A	459.08 A	0.8	1.1	1.1	10 %
Day II	429.45 A	583.31 A	475.63 A	496.13 A	0.9	1.2	1.0	9 %
Day III	415.9 A	516.06 A	516.62 A	482.86 A	0.9	1.1	1.1	9 %
Day IV	436.65 A	498.15 A	552.66 A	495.82 A	0.9	1.0	1.1	8 %

Based on the data of the three-phase current imbalance presentation, it is obtained that the magnitude of the presentation exceeds the allowable requirements as mentioned in the IEC 6100 standard, namely the imbalance of three-phase loading should not exceed 5%.

Therefore, seeing the percentage value is quite large, POLNAM should pay attention to this phenomenon and solve the problem. One way that can be done to balance the load is to observe which phase is more and less burdened. Based on the data, phase S and phase T tend to have higher current values and power consumption than phase R. So it is better if some loads in phase S and T are transferred to phase R so that a more balanced three-phase loading is obtained. However, if the load transfer is not done and if there is an additional load (sub distribution), the load should be entered into the R phase.

Harmonisa

The three-phase current curve based on the wave recording results shows that the curve is not perfectly sinusoidal. The current wave experiences distortion or defects due to frequencies other than the fundamental frequency of 50 Hz. When viewed in the frequency domain based on the recorded data, it is found that there is a default frequency above 50 Hz with dominant presentation values, namely frequencies of 150 Hz, 250 Hz, 350 Hz, etc. or in harmonic order are the third, fifth, seventh, etc. harmonics (odd harmonics). The presentation can be seen in the following table along with the Total Harmonic Distortion (THD) presentation.

Table 5. Measurement of Current Harmonics

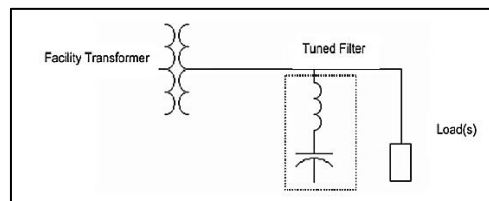
Measuremet Time	% D-3	% D-5	% D-7	% THD
Dayi I				
R	7.07	5.02	2.19	10.1
S	10.11	4.85	2.55	11.54
T	9.05	4.33	1.43	11.48
Day II				
R	5.11	5.24	3.00	10.75
S	10.65	3.26	2.43	10.10
T	8.14	5.3	1.80	12.04
Day III				
R	8.19	3.89	0.65	11.72
S	10.94	3.81	2.42	11.39
T	10.81	4.25	1.81	11.35
Day IV				
R	6.23	5.73	2.48	12.3
S	12.74	3.87	2.11	10.47
T	7.52	5.39	1.27	11.1

Based on these data, the % THD tolerance limit refers to the IEEE 519-1992 standard which states that the % THD tolerance limit contained in the system is 5% (Adi Wirajaya et

al., 2019). Based on these limits, it is certain that there is a current harmonic disturbance in the polnam electrical system which is indicated by the percentage of harmonic distortion which is quite high up to 12.3%.

The cause of the high THD due to the inherent frequency in the current wave is due to the characteristics of nonlinear loads. Nonlinear loads such as electronic equipment produce current waves that are not the same as pure sinusoidal voltage waves due to the switch process. As a result, other frequencies appear in the current wave which causes the current wave to be distorted.

We cannot deny that in the POLNAM environment, the use of nonlinear loads is certainly the majority to support the implementation of academic activities. Electronic equipment is often found in office work or in laboratories and workshops. Therefore, its presence cannot be minimised. One way to overcome current harmonics is to install compensation equipment, namely harmonic filters that are tuned to inherent frequencies that are dominant in nature such as the frequency of 150 Hz (third harmonic) and the frequency of 250 Hz (fifth harmonic). This tool is known as a passive filter which consists of passive components Resistor R, capacitor C, and inductor L.



Use of passive filters to reduce harmonics

CONCLUSION

Based on the research activities carried out, namely power quality analysis in the Ambon State Polytechnic building, it can be concluded:

1. The results of measuring and recording waves of current, voltage, and power show the characteristics of the existing electrical system at POLNAM. These results can help analyse whether these parameters are in normal or disturbed conditions.
2. Through data tabulation and analysis, it is found that there are several abnormal conditions in the voltage, current, and frequency of the system due to the amount that is outside the specified standard. There are voltage disturbances including voltage dip with a large voltage drop of up to 24.4% and there are also flickers which of course these two voltage disturbances affect the operation of equipment because electrical equipment works at constant voltage. There is also a current disturbance, namely current imbalance due to unbalanced loading on a three-phase system which results in a current on the neutral wire. The amount of current imbalance reaches 10%, far from the tolerance limit of 5%. Current harmonic disturbance is also quite high with % THD reaching 12.3% exceeding the required tolerance of 5%.
3. The results of tabulation and further analysis can be used by researchers to recommend handling of these disturbances ranging from choosing the right electric motor starting method to minimise high starting currents, installing DVRs for voltage improvement, switching loads to overcome imbalances, and installing passive filters to overcome harmonics.

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