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HARMONIC DISTORTION AS A REFERENCE FOR THE QUALITY OF THE ELECTRICAL DISTRIBUTION SYSTEM IN THE PT. GOJEK TOKOPEDIA LOGISTICS

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Abstrak. Masih kurangnya penelitian tentang distorsi harmonik yang mempengaruhi kualitas listrik pada suatu gedung. Distorsi harmonik ini disebabkan oleh beban nonlinier, yang akan terutama mempengaruhi peralatan elektronik. Pada main distribution panel (MDP) di suatu gedung, untuk mendapatkan informasi, distorsi harmonik total dalam tegangan (THD-v) dan distorsi harmonik total dalam arus (THD-i) diukur secara langsung. Pemeliharaan dan pemeriksaan rutin akan memperoleh data yang dapat dievaluasi sehingga sistem selalu dapat diandalkan. Dalam kasus gedung PT. Gojek Tokopedia Indonesia, hasil pengukuran pada 20-05-2023 menunjukkan bahwa jumlah THDi pada fase R di MDP adalah 64,56%. Menurut standar IEEE std 519-1992, arus listrik yang diizinkan adalah 15%, jadi dalam solusi dengan Filter Harmonik (H.F.), perubahan arus listrik pada fase R menjadi 12,37%. Dengan menggunakan filter harmonik pada nilai induktor (L) sebesar 0,28 mH dan nilai kapasitor (C) sebesar 2 mF, faktor daya meningkat menjadi 0,99 dari 0,85. Karena hal ini, setiap manajer gedung dan pemeliharaan harus memberikan perhatian rutin pada nilai THD sesuai dengan standar yang berlaku.

Abstract. *However, little research has been done on how harmonic distortion affects the electrical quality of buildings. This harmonic distortion is caused by nonlinear loads, which will mainly affect electronic equipment. At the building's main distribution panel point (MDP), To obtain information, total harmonic distortion in voltage (THD-v) and total harmonic distortion in current (THD-i) were measured directly. Regular Maintenance and checks will obtain data that can be evaluated so that the system is always reliable. In the case of the PT Gojek Tokopedia Indonesia building, the measurement results on 20-05-2023 showed that the number of THDi in phase R at MDP is 64.56%. According to the IEEE std 519-1992 standard, the permissible electric current is 15%, so in the solution with Harmonic Filter (H.F.), the change in electric current in phase R becomes 12.37%. Using a harmonic filter in the inductor (L) value of 0.28 mH and capacitor (C) value of 2 mF, The power factor increases to 0.99 from 0.85. Because of this, every building manager and Maintenance must pay regular attention to the THD value according to applicable standards.*

1. INTRODUCTION

Dokumen The quality of electrical power is an essential factor for consumers. The quality of electrical power systems regarding voltage, current, and frequency is critical [1]. Power quality control technology results in better THD reduction based on IEEE 519 standards [2]. Power systems frequently encounter problems with voltage, including voltage dips, distortion, imbalance, and fluctuations [49]. These have the potential to harm transformers, generators, industrial loads, and residential loads [3]. Power quality (PQ), as defined in IEEE-1159-2019 recommended practice [4]. In the end, it's a customer-driven problem with the primary goal of giving customers quality power [5].

A reliable electrical system is characterized by sufficient power capacity. A reliable system must ensure sufficient electrical power capacity to meet the electrical needs of the building [6]. A reliable system must be efficient in allocating electrical power. This includes using appropriate technology, minimizing power losses, and optimizing operations [7]. The capacity of the energy source and the control method determine how much electrical energy is supplied into the power system [8]. Highlighting the need for demand response to be taken into account when the distribution system is designing its capacity [9].

Harmonic distortion is caused by nonlinear loading. Nonlinear loading can result in harmonic distortion, hurting electrical power quality. In addition to changing loads, harmonic distortions will affect various electrical equipment and increase power losses in the system [10]–[14]. The transmission/distribution system's power quality is reduced by these harmonic-generating loads. [15]–[17]. The outcomes demonstrate how the suggested strategy is superior than traditional methods: enhanced power quality, reduced harmonics, and enhanced dynamic voltage responsiveness [6], [20]. Total Harmonic Distortion (THD) monitoring determines the lavel of power quality [18] – [20]. Reactive power is produced by increased harmonic distortion of the current, which reduces the power factor [19].

Too high harmonic levels will cause interference with electrical equipment, including transformers [20]. The findings demonstrate how the suggested technique performs better in terms of enhanced power quality than conventional approaches, reduced harmonic distortion, and increased dynamic voltage responsiveness [18], [21].

Building Maintenance ignores the load installed. Maintenance policies that do not cover installed loads can lead to ineffective Maintenance and do not correct problems that affect the balance of the distribution system [21]. It is essential to pay attention to the installed load in building maintenance activities to guarantee the dependability and safety of the electrical system [21], [22]. Seldom was the impact of harmonic distortion on distribution of electric power networks seen. The main parts of the electric power distribution system that are affected by harmonic distortion are non-sinusoidal currents and voltages, which can interfere with some aspects of the system, reduce transformer efficiency, lower power factor, and increase voltage drop [12], [23]–[27].

Load imbalances cause harmonic distortion that causes equipment heat and system disturbances. Increased heat because of harmonic distortion in the electrical power system can reduce system reliability and performance [28]–[30]. Therefore, for safety reasons, we should try to have as few harmonics as possible [2], [10], [31]–[35].

The presence of a poor power factor can interfere with sensitive equipment and affect the performance of other equipment. Equipment that requires active power (such as electric motors) will experience decreased performance due to excessive reactive power [5], [22], [33], [36], [37]. In addition, Low power factor can also cause energy losses and increase electricity costs [38]–[41].

Constantly changing loads cause voltage fluctuations. A momentary interruption is a very brief loss of power, but it can cause damage to sensitive equipment [38] [42]. Load imbalances in the electric power distribution system can cause voltage fluctuations, which can provoke harmonic distortion [6], [12], [43]–[45]. Harmonic distortion occurs when current and voltage waves are no longer purely sinusoidal, which can result in increased heat in the system [38], [41], [46], [47]. Load imbalance can cause voltage fluctuations, which can affect the electrical equipment's performance and raise the risk of system failure [38], [48], [49]. As a result, It is crucial to keep the power distribution system's load balance intact to avoid voltage fluctuations and harmonic distortion, which can cause damage [3], [6], [7], [14].

This research is needed because of the importance of regulating 3-phase electrical loads in buildings. With proper load setting, it can avoid current imbalance at each phase [12]. One of the solutions for the ketidakseimbangan tegangan case is to maintain the transition between phases in the MDP participant [43]. This imbalance can cause damage to equipment and reduce efficiency [6]. The use of a 3-phase electrical system allows greater power consumption and is suitable for industrial, office, building, and hospitality needs [11], [36]–[38].

Knowing the impedance of electrical loads and implementing harmonic filters can help remove unwanted harmonics from the electrical system in buildings. The impedance is relatively high, thus causing a voltage drop in power lines [43]. The linear load in this instance is represented as an impedance using a series combination of reactance and resistance [50]. Harmonic voltage drops at the system impedance result in voltage disturbances that cause other linear loads [15], [34], [51]. Furthermore, the inductance of the line undergoes a slight change after the replacement of the conductor [52].

With the harmonic filter tool, the inductance and capacitance values will be obtained to improve the power factor. [38]. By accurately measuring and analyzing electrical power, it is possible to manage electricity consumption more efficiently. [36]. Such harmonic distortion of current further increases reactive power, thereby lowering the power factor [5], [19], [22], [33], [36], [37]. Because of its high power density, low harmonic distortion, great efficiency, and high power factor, this technology is always changing [1], [38], [39], [53].

It requires measurement results with a Power and Harmonic Analyzer tool so that it can be analyzed and solutions using harmonic filters. The analyzer should follow the manufacturer's standards to get the expected results. [20]. Harmonics can also cause damage to power systems, a drop in efficiency, and a shorter component life for power plants [15], [57]. The reduction of harmonic currents from the model used shows that the system is suitable and valid [54] [33]. The harmonics to be compensated must be known in order for the active power filter (APF) to function correctly [19], [37], [48], [55], [56], [57]. As a result, for harmonic suppression, the LCL filter outperforms the RL filter [8].

2. LITERATURE REVIEW

Harmonic distortion refers to the deviation of voltage or current waveforms from their ideal sinusoidal shape due to the presence of harmonics frequencies that are integer multiples of the fundamental frequency [2], [3], [6]. [55]. These distortions are primarily caused by nonlinear loads such as: Variable frequency drives (VFDs), Uninterruptible power supplies (UPS), Computers and other digital electronics. Harmonic distortion can significantly affect the performance and reliability of electrical distribution systems: Increased losses in transformers and conductors, Overheating of equipment, Malfunctioning of sensitive devices [6], [8], [17], [32]. Reduced efficiency and lifespan of infrastructure

3. RESEARCH METHOD

This research uses a measurement approach, and research can take a quantitative approach by measuring directly at the PT Gojek Tokopedia Logistics building. Researchers collect data from the literature on harmonic distortion, electrical power quality, and their effects on similar buildings. Data analysis from previous literature and case studies can provide insight into PT's problems. Gojek Tokopedia Logistics. The respondents involved in this research were assisted by the management of PT. Gojek Tokopedia Indonesia and electrical and mechanical experts of PT. Gojek Tokopedia Indonesia

Total Harmonic Distortion (THD) values for voltage and current at different MDP points throughout the building can be obtained by directly measuring data with the Power and Harmonic Analyzer device. The data obtained are then analyzed to understand the impact of harmonic distortion on electrical power quality. Data analysis uses measurement and calculation results to be compared with measurement results. Solutions to reduce high current THD with Harmonic Filters will get L and C values. The excellent impact of increasing THDi will also increase the power factor's value.

4. RESULTS AND DISCUSSION

The following devices can be used to measure the power consumed and the quality of electrical waves.

Fig. 1. Power and Harmonic Analyzer

Whatever measurement results are obtained, as in Table 1 of voltage and current measurements in MDP.

Table 1. Measurement of voltage and current

	Volt Phase R-S	Volt Phase S-T	Volt Phase T-R	Ampere Phase R	Ampere Phase S	Ampere Phase T
Max	399,2	400,5	396,7	122,6	121,4	122,8
Date	19/05/2023	20/05/2023	19/05/2023	20/05/2023	19/05/2023	19/05/2023
Time	19:35:00	04:25:00	18:35:00	07:55:00	17:15:00	17:15:00
Min	388,1	389,2	386,4	113,7	115,7	115,9
Date	19/05/2023	19/05/2023	20/05/2023	19/05/2023	19/05/2023	19/05/2023
Time	13:10:00	13:10:00	13:10:00	19:35:00	19:45:00	18:10:00
Average	394,4	395,6	392.4	116,5	118,1	118,7

Furthermore, the results of measuring power, cos phi, frequency, v-THD, and i-THD are shown in Table 2 below.

Table 2. Max and Min Power Measurement, Cos pi, Frequency, V-THD and I-THD

DAYA			COS φ	FREQUENCY	V-THD %	I-THD %
WATT	**VA**	**VAR**				
69.400	**69.630**	**8.610**	**1,00**	**50,13**	**3,49**	**67,03**
20/05/2023	19/05/2023	19/05/2023			20/05/2023	19/05/2023
07:55:00	17:55:00	16:05:00			17:15:00	23:20:00
66.390	**66.440**	**1.770**	**0,99**	**49,93**	**2,69**	**58,30**
19/05/2023	19/05/2023	20/05/2023			19/05/2023	20/05/2023
67.067	**67.127**	**2.635**	**1,00**	**50,01**	**3,14**	**64.56**

The following are the current measurement results on MDP shown in Figure 2

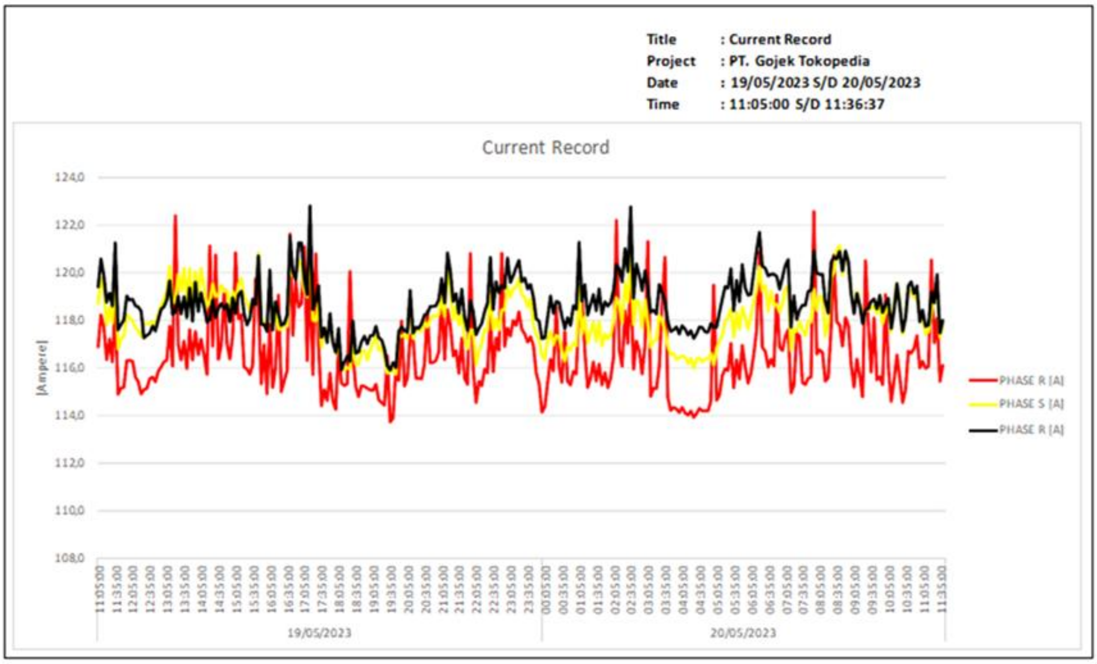

Fig. 2. Current Usage Graph on MDP (Main Distribution Panel)

In the Power analyzer on the MDP panel with a capacity of 400A, the results obtained are made an average, as shown in Table 3 below

Table 3. Max and average flow per phase Current Record (Ampere)

Current Record (Ampere)			
	PHASE R	PHASE S	PHASE T
MAX	122,6	121,4	122,8
DATE/TIME	20/05/2023 07:55:00	19/05/2023 17:15:00	19/05/2023 17:15:00
MIN	113,7	115,7	115,9
DATE/TIME	19/05/2023 19:35:00	19/05/2023 19:25:00	19/05/2023 18:10:00
AVERAGE	116,5	118,1	118,7

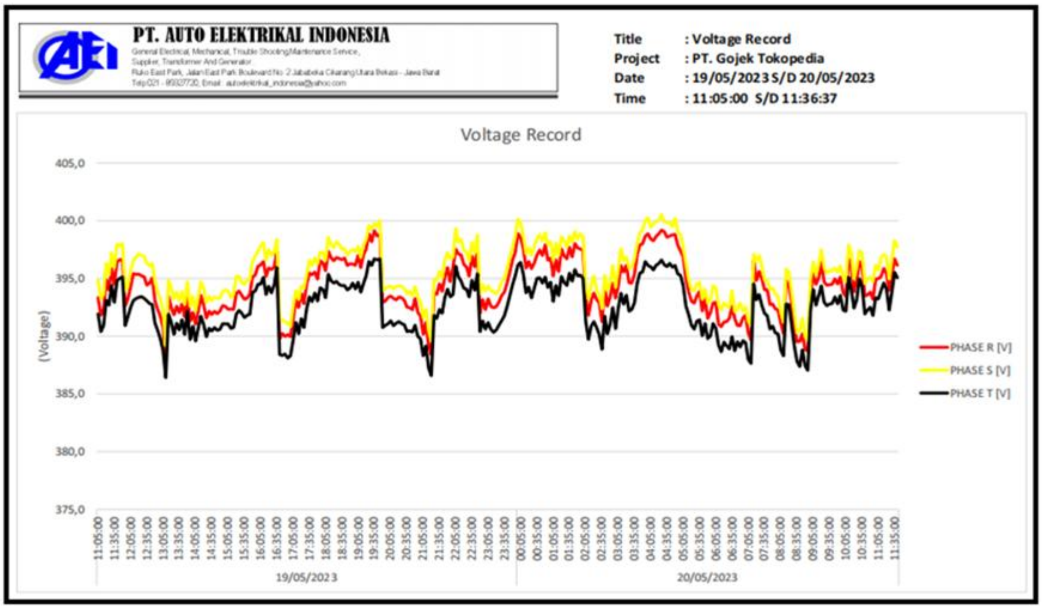

Fig 3. displays the voltage measurement results on MDP

Table 4. Maximum and average voltage measurement on MDP

Voltage Record (Voltage)			
	PHASE R	**PHASE S**	**PHASE T**
MAX	399,2	400,5	396,7
DATE/TIME	19/05/2023 19:35:00	20/05/2023 04:25:00	19/05/2023 19:35:00
MIN	388,1	389,2	386,4
DATE/TIME	19/05/2023 13:10:00	19/05/2023 13:10:00	20/05/2023 13:10:00
AVERAGE	394,4	395,6	392,4

3.1 Voltage analyzer

Figure 4 below shows the results of the THD voltage measurement

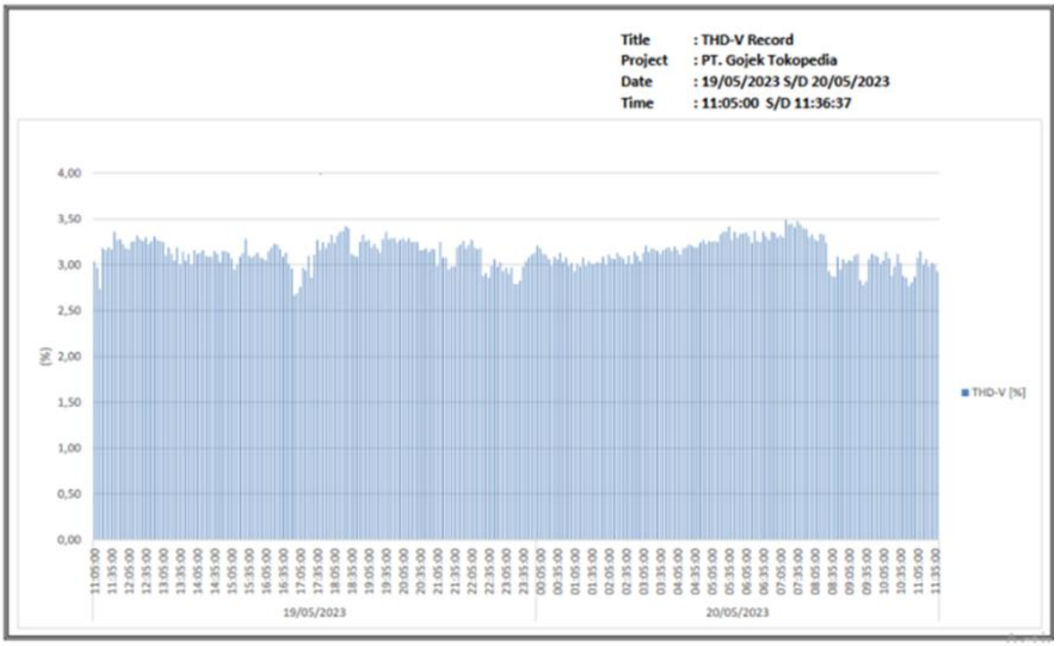

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Fig. 4. THD-v voltage measurement

Furthermore, the average result of THD-v voltage is shown in Table 5. Then, the result of harmonic distortion voltage of 3.14% is obtained

Table 5. Flat tension (THD-v)

THD-V RECORD (%)	
MAX	3,49
DATE/TIME	20/05/2023 17:15:00
MIN	2,67
DATE/TIME	19/05/2023 16:55:00
AVERAGE	3,14

The data obtained for voltage under normal conditions based on the data from the measurement of the average value per phase using this power analyzer shows the balance of Voltage (Voltage) in Phase to Phase under normal conditions is only 0.40%. This refers to the NEMA MG-1-1993 standard, which has a ≤ tolerance of 2%. This means that the voltage between Phases is very well measured.

Based on the results of measuring the average value of THD voltage using a power and harmonic analyzer, the average THDv value looks NORMAL because it does not exceed ≤ 5% (IEEE std 519-1992).

3.2 Electric current analysis

The results of the THD-i current measurement are shown in Figure 5 below

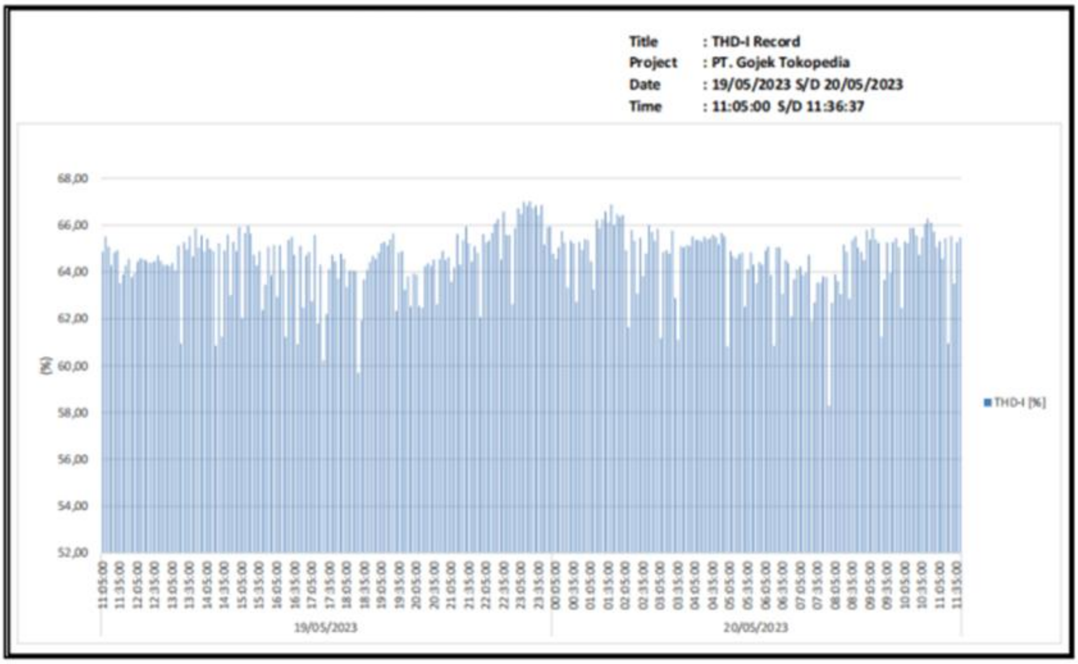

Fig. 5. THDi Measurement Graph on MDP

The maximum and average current values of THDi are shown in table 6 below

Table 6. Max and average current values of THDi in MDP

THD-I RECORD (%)		
MAX	67,02	
DATE/TIME	19/05/2023	23:20:00
MIN	58,30	
DATE/TIME	20/05/2023	07:55:00
AVERAGE	64,56	

From the average ampere data per phase, table 3 is still below the available capacity of 400A. This Current imbalance shows the balance from Phase to Phase under normal conditions of 0.66%. This refers to the NEMA MG-1-1993 standard, which has a ≤ 10% tolerance.

So that THDi results are obtained on the MDP panel of PT. Gojek Tokopedia Logistics amounted to 64.56% from Table 6. However, concerning the harmonic content of measurements using a power and harmonic analyzer, the average THDi value looks ABNORMAL because it exceeds ≤ 15% (IEEE std 519-1992). To overcome this harmonic, it is necessary to install a harmonic filter (harmonic filter) and improve the existing power factor. If the existing power factor is measured at 0.85 and wants to be improved to 0.99, then an inductor filter (L) of 0.28 mH and capacitor (C) of 2mF and harmonic distortion from 64.56% will be 12.8%.

5. CONCLUSION

Regulation of the electrical load of each phase on MDP is needed to maintain the quality of the distribution electricity system. According to applicable standards, maintain Electric voltage fluctuations of less than 5% and THDi values of less than 15%. The company management of a building must prepare a Harmonic Filter and Power and Harmonic Analyzer. Observation and Maintenance of the THD value of electric current in a building must be routinely done so that if there is a problem, one of the phases in MDP will be easily overcome with a Harmonic Filter, as in the building PT. Gojek Tokopedia Indonesia.

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