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# Assessment of Power System Equipment to Enhance the Power Quality at Dr. Saiful Anwar General Hospital Malang

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***Abstract***

*Electrical conditions in the operations building and substation of the regional general hospital Dr. Saiful Anwarexperienced a power cut at optimum load, resulting in the power supply being solely obtained from the generator. The aim of the assessment carried out was to delve deeper into power quality, electrical performance, and other supporting equipment to maximize service to patients based on the assessment findings. The assessment stages utilized were the initial assessment stage and the detailed assessment stage. The analysis stages were conducted under steady-state load conditions. The assessment process involved field measurements, observations, and interviews with technical staff at the general hospital Dr. Saiful Anwar. Field measurements utilized Ammeters, Voltmeters, and Harmonic Analyzers to ascertain voltage imbalances, current imbalances, and harmonic content in SDP panels on each floor of the operations building, as well as to evaluate UPS components as backup power and stabilizers for electrical equipment. The results of observations and direct measurements in the field revealed several issues, including a current harmonic content of up to 50% on the 6th floor of the operations building (OK6) and in the Linac room, along with various other findings related to voltage and current imbalances in the secondary substation and certain components. The UPS, alike to the battery and filter capacitor inside, requires replacement. Additionally, regarding the grounding value, which currently stands at 3 Ohms, it is imperative to incorporate a parallel grounding system to bring the value below 1 Ohm to mitigate the risk of leakage current occurrences.*

***Keywords:*** *Assessment, Harmonics Analysis, Power Quality, Substation*

**Abstrak**

Kondisi kelistrikan pada gedung operasi dan gardu 25 Rumah Sakit Umum Daerah Dr. Saiful Anwar mengalami pemutusan tenaga pada saat beban optimum yang menyebabkan suplai daya hanya didapatkan dari generator saja. Pada asesmen yang dilakukan ini bertujuan untuk mengetahui lebih dalam mengenai kualitas daya, performa kelistrikan, dan peralatan penunjang lainnya sehingga selanjutnya dari asesmen yang dilakukan dapat memaksimalkan pelayan terhadap pasien. Tahapan asesmen yang digunakan yaitu tahapan asesmen awal dan asesmen detail. Tahapan analisis dilakukan terhadap kondisi beban saat keadaan *steady*. Proses asesmen dilakukan melalui pengukuran lapangan, pengamatan, dan wawancara kepada tenaga teknik Rumah Sakit Umum Daerah Dr. Saiful Anwar. Pengukuran di lapangan menggunakan peralatan Amperemeter, Voltmeter, dan *Harmonic Analyzer* untuk mengetahui ketidakseimbangan tegangan, ketidakseimbangan arus, kandungan harmonisa pada panel SDP di setiap lantai di gedung operasi, dan melakukan evaluasi terhadap komponen UPS sebagai daya cadangan serta stabilisator di setiap lantai untuk suplai kelistrikan peralatan medis. Hasil observasi serta pengukuran langsung di lapangan di temukan beberapa masalah yaitu kandungan harmonisa arus yang mencapai 50% pada gedung operasi lantai 6 (OK6), dan ruang Linac serta beberapa temuan lain terkait permasalahan ketidakseimbangan tegangan dan ketidakseimbangan arus pada gardu 25 sisi sekunder serta beberapa komponen UPS seperti baterai dan filter kapasitor didalamnya yang harus untuk diganti. Terkait dengan nilai pentanahan yang masih bernilai 3 Ohm, perlu dilakukan penambahan paralel sistem pentanahan agar nilainya bisa dibawah 1 untuk mengantisipasi terjadinya tegangan sentuh.

**Kata Kunci:** Asesmen, Analisis Harmonisa, Gardu Distribusi, Kualitas Daya

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## INTRODUCTION

Regional general hospital Dr. Saiful Anwar is one of the leading hospitals in Malang city, East Java, Indonesia. This hospital is equipped with advanced medical facilities and equipment to provide quality health services to patients. Available facilities include emergency units, inpatient care, operating rooms, laboratories, radiology, as well as various other medical and paramedical services. Other facilities also provide a variety of health services ranging from routine check-ups, treatment of common illnesses, to handling more complex medical cases. Apart from that, this hospital also has public health and educational programs to increase awareness of the importance of health. This hospital continues to follow the latest developments in medical technology and updates the equipment and systems used to ensure optimal service to patients. General hospital Dr. Saiful Anwar is committed to providing quality and comprehensive health services to every patient. They also strive to continuously improve service standards through training and internal evaluation. The quality of health services for the entire community must always be improved as part of the efforts of each delegated party. One factor that needs to be considered to support efforts to improve the quality of health services is the provision of quality electricity facilities. Electricity quality indicators include guarantees of reliability, stability and safety in its use. The reliability and safety of an electrical system can be determined by carrying out regular maintenance, and calibration. (Suprayogi, M. R., 2014)

Electrical energy is one of the basic energies that supports human life. Power quality has become an important part of a power system (Basyarach et al., 2023). The quality of electrical power supplied from PT. PLN (Persero) and the quality of electrical power from the customer side, which is influenced by the customer's load, must comply with the regulations set by the government. According to Ewald F. Fuchs and Mohammad A.S Masoum (2011), electrical power quality is power quality which is generally meant to be defined as: size, analysis and increase in bus voltage to maintain sinusoidal waves in voltage, current and frequency. The quality of power is the most important thing in the world of electricity today. Where apart from the government as a supplier of electrical power supply which must meet good electricity quality, consumers must also be able to maintain and utilize the quality supplied by the government, especially PLN. Non-linear loads are one of the important factors that influence the quality of electrical power for consumers. This load is a source of harmonics which can reduce the quality of electrical power. To create good quality electrical power, you need to carry out an electrical network assessment. The assessment carried out includes identification of the quality of voltage, current, frequency, power factor and harmonics (Yudha H.M., 2017).

General hospital Dr. Saiful Anwar carries out the mission of being a center for health services for the entire community regardless of background. Seeing its function which is an important component in supporting health for the general public and currently the quality and reliability of the electricity network is unknown from the time it was formed, the general hospital Dr. Saiful Anwar Malang needs to carry out an electrical network assessment so that later an evaluation can be carried out on the quality of the electrical power in the building. The purpose of this assessment is to conduct an audit of the quality of electrical power in the operations building and substation 25. So, the benefit of the assessment carried out is to find out the profile of the quality of electrical power in the operations building and substation 25 at the Regional General Hospital so that it can increase the efficiency of electrical energy use and improve the quality of electrical power. From these benefits, it is hoped that Hospitals can carry out evaluations, so that health services will be more guaranteed.

## METHODS

The electrical network assessment was carried out at the regional general hospital Dr. Saiful Anwar which is part of the health services managed by the East Java province located on Jl. Jaksa Agung Suprapto No. 2, Malang city, East Java. This assessment will be carried out in January 2023 for 3 days. The assessment is carried out using a quantitative descriptive method which will explain the results of the percentage description. Data from this assessment process was obtained by direct testing in the field. This test will obtain the measurement results of each SDP panel and then compare them with IEEE 519 – 2014 and PLN standards to determine the quality of electrical power in the building (Ashar A. R., 2018). In carrying out this assessment, tools and materials are needed to carry out measurements on the LVMDP panel. The tools and supporting materials used in the test are the Harmonics Analyzer Hioki 3286. Apart from using the Hioki 3286 Harmonics Analyzer to measure the harmonic content. To see the Unbalanced Voltage due to uneven loads in each phase and to observe the health of the battery in UPS equipment to determine whether the condition is overcharged or not, a measuring instrument in the form of a voltmeter is needed. Then, to carry out an assessment of the current limit capacity adjusted to the Circuit Breaker or to see the leakage current in the neutral wire due to unbalanced loading, we need a Ammeter.


(a) (b)

Figure 1. Measuring tools used : (a) Harmonics Analyzer and (b) AVO Meter

Data processing and analysis is carried out to answer several problem formulations. After knowing the parameter values of the measurement results, they are then compared with the SPLN and IEEE 519 – 2014 standards (Sihombing et al., 2023). If there are measurement parameter values that do not comply with the standards, then analyze the cause and provide a solution as a recommendation if the regional general hospital Dr. Saiful Anwar Malang wants to make electrical repairs.

## RESULT AND ANALYSIS

Based on applicable regulations, several standards are used in carrying out assessments. The following electrical standards are used in the assessment:

a. SNI 04-0225-200 (PUIL 2000)
b. IEC 60364-7-710 : Requirements for Special or location Medical Location
c. Republic of Indonesia Minister of Health Regulation No: 2306/MENKES/PER/XI/2011 concerning Technical Requirements for Hospital Electrical Installations
d. IEEE 519 – 2014 : Harmonics Standard.

In determining the quality of electrical power supply, there are several things that must be fulfilled during operational conditions, some of these parameters are:

1. Capacity must be in accordance with what is needed

2. Good frequency voltage current quality
3. High network system reliability
4. Security and benefits are guaranteed
5. Prioritize energy saving

**1. 6th Floor Surgical Building Assessment Results**

Harmonic assessment in hospitals is an evaluation process carried out to ensure that various medical and non-medical equipment components in the electrical system can function in accordance with IEEE 519 - 2014 standards. The main objective of harmonic assessment is to improve efficiency and power quality in supply electrical energy services in hospitals. After taking measurements on the SDP panel of the 6th floor surgical building, it is presented in Table 1. There are several color differences in the table presented, namely green means that the harmonic content in the SDP of the 6th floor surgical building is still within the applicable standards, while in the red table the harmonic content has exceeded the IEEE 519 – 2014 standard.

Figure 2. The process of measuring harmonic content with a harmonics analyzer

**Table 1. Harmonic Content Assessment Results**

| Orde | Voltage Harmonics | Current Harmonics |
|---|---|---|
| 3 | 1,2% | 54,7% |
| 5 | 1,2% | 60% |
| 7 | 1,2% | 60,2% |
| 9 | 1,2% | 61,1% |
| 11 | 1,1% | 57,7% |
| 13 | 1% | 57,6% |

Table 1 explains the results of harmonic measurements with the help of a harmonics analyzer measuring instrument. The voltage harmonic content is still far below the standard, namely based on the IEEE 519-2014 standard for voltages below 1 kV. The permitted harmonic content limit is 8%, while the measured harmonics are an average of 1%. On the other hand,

when measuring the current harmonic content, the value is 3 times the permitted standard. The standards applied to current harmonics are according to IEEE standard 519 – 2014 with a value of iL/i_SC > 1000 with an operational voltage of 120 V – 69 kV, namely with a maximum limit of only 15% (Widagdo & Andriawan, 2023). However, the harmonic content of all equipment connected to the SDP panel of the 6th floor operations building is above 50%. So from these conditions, several indications that cause the magnitude of the harmonics are due to:

a. The capacitor filter at the UPS output is not working optimally
b. It's time to replace the battery (Accu) as a UPS supply
c. Equipment grounding is not installed separately

Indications related to capacitors that do not work optimally cause the wave at the inverter output to not be filtered perfectly so that the pure sinusoidal wave is distorted and affects the measurement value of the harmonic content which is above the applicable standard. Then grounding equipment that is not installed separately causes harmonics originating from outside the grounding of the 6th floor surgical building to increase the harmonic in the SDP panel of the 6th floor surgical building. The recommended solutions to improve this condition so that the quality of electrical energy supply is maximized are given several suggestions (Widagdo & Budiono, 2023) :

a. Replacement capacitor in UPS (Cap-Inverter) compartment
b. UPS battery replacement
c. Installation of special capacitors (filters) for harmonic networks

Filters in the context of power systems can be used to reduce harmonic values. Harmonics are additional frequency components that appear in a signal due to distortion or non-linearity in the system. Reducing harmonic values is important in applications such as electric power systems to maintain signal quality and avoid interference. The appropriate filter depends on the signal characteristics and application requirements. Some applications may require a combination of some of the above techniques to achieve effective harmonic reduction (Widagdo & Setyadjit, 2023).

## 2. Assessment of Uninterruptible Power Supply (UPS) conditions

In another assessment related to UPS performance, measurements were carried out on the battery section, it was found that an overcharge had occurred. In Figure 3, when measuring the battery voltage, it can be seen that the battery for the UPS on the 6th floor of the operating building experienced an overcharge with a measured voltage value of 13.69 Volts, whereas when compared to the 4th and 5th floors the battery voltage was still in operating condition, namely 13. 64 Volts, this shows that there is a battery on the 6th floor as a UPS supply which is not operating optimally so it is recommended to replace the battery so that the UPS can back up optimally.


Figure 3. Measure the condition of the UPS on the part of the battery that is overcharged

Figure 4. Condition of the UPS in the surgical building of regional general hospital Dr. Saiful Anwar Malang after the fire occurred

Assessing equipment on a UPS is important to ensure that the system functions optimally and can provide the necessary protection against power interruptions. From the results of the assessment carried out, the fire occurred due to overload or known as exceeding the capacity of the UPS equipment and also the inappropriateness of the UPS used. In Figure 4 there is a UPS type with a Transformer-less UPS type, while the UPS which should be used for types of equipment that have a large current rating value uses a UPS type with a Transformer-based UPS type.

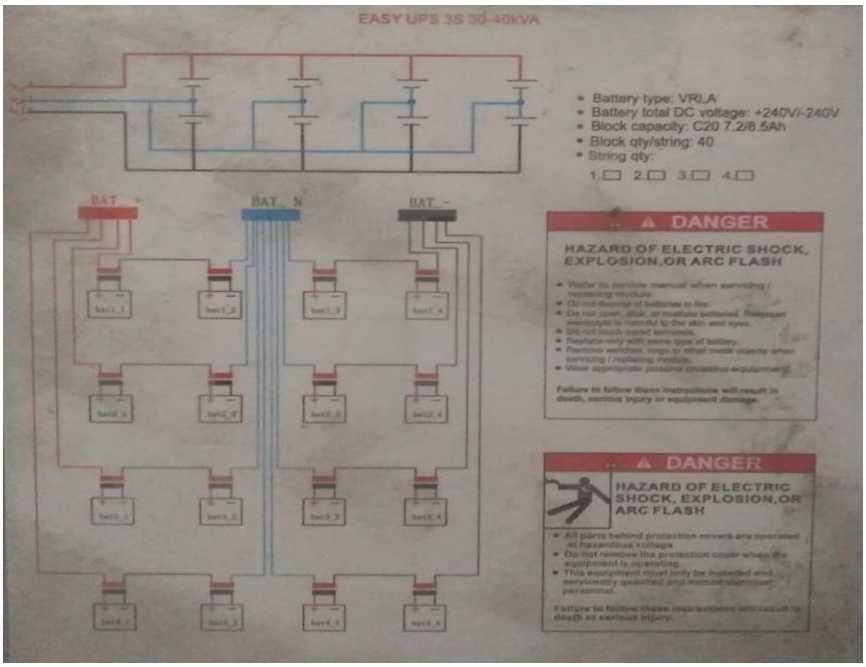


Figure 5. The Equivalent Circuit of a Transformerless UPS burns out.

In the context of power system security, the choice between transformer-based and transformer-less UPS must consider the specific needs of the system and equipment being protected. Transformer-based UPS can provide better galvanic isolation protection, while transformer-less UPS can provide higher energy efficiency and lighter weight (Handayani et al., 2022).


Figure 6. The expert team conducted surveys and interviews directly in the field

The security of an electric power system depends not only on the type of UPS used but also on routine maintenance, proper selection of the load, and any additional security measures that may be required. Transformer-based UPS and transformer-less designs provide fundamental functionality and maintain their respective characteristics. It is clear that transformer-less UPSs dominate the market today. Transformer-less UPSs meet most of today's power supply design requirements, but for applications that require the highest reliability and safety such as the medical field, transformer-based UPS are the right choice (Yulianto, 2023).

From the results of the assessment, several evaluations need to be followed up, these evaluations are described in the following points:

1. It is necessary to test the battery capacitance either with an internal load or by bypass with the help of an external load.
2. Because the operating temperature of the battery so that it can work for at least 6 years is $25^0$C, it is recommended to provide air conditioning and maintain the room temperature at $25^0$C.
3. Additional devices need to be provided including temperature sensors and voltage sensors to be able to monitor the minimum temperature of the battery when operating and voltage sensors are used to prevent overcharge.

## 3. Assessment Results at Distribution Substation Number 25

Assessment of Distribution Substations is an evaluation and assessment process carried out to ensure that electricity distribution substations operate efficiently, safely and in accordance with established standards. This assessment can involve various aspects, including physical infrastructure, electrical equipment, protection systems, security, and operational reliability. Several assessments have been carried out by the assessor team:

1. Conduct an assessment of infrastructure and equipment: Condition of transformers and monitoring equipment
2. Operational reliability: Monitoring electrical load and substation capacity
3. Compliance with standards: Ensure that distribution substations comply with applicable safety and performance standards.

This assessment can be carried out by a trained and experienced inspection team. The results of the Distribution Substation assessment are used to make recommendations for necessary repairs or improvements to ensure safe and reliable operation (Siregar & Harahap, 2017).


Figure 6. Monitoring voltage and current parameters that indicate unbalanced load

From the results of the field analysis, there was a problem of load distribution unbalanced at Substation 25. From the evaluation results, several points were obtained that needed further attention:

a) Unbalanced voltage occurs, the consequences are dangerous for medical equipment that requires a supply voltage of 220 V
b) The current of each phase is not balanced, as a result there will be a current flowing in the neutral wire
c) The power factor according to PLN standards, namely pf ≥ 0.85 lag

## CONCLUSION

From several assessment results that have been carried out, several conclusions can be drawn so that they can be used as recommendations for maintenance steps:

1. From the results of measurements on several floors of the operating room, it was found that the current harmonic content (THDi) on the SDP side was quite large, above the IEEE standard, namely 15%, however the voltage harmonic content (THDv) already met the IEEE standard, below 8%.
2. Several UPS systems in all operating rooms are recommended to use parallel systems to anticipate if the main UPS experiences failure to provide back-up to medical equipment.
3. There is a load imbalance on the substation 25. This case can cause an unbalanced voltage condition, as well as an unbalanced current supply which can cause current to flow in the neutral wire.

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