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Qualidade de energia analisada do navio ahts do sistema elétrico

Analysed power quality of electrical system ahts vessel[1]

Calidad de energía analizada del sistema eléctrico en su buque

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Resumo

Vários problemas de qualidade de energia, incluindo harmônicos elétricos, fator de potência ruim e instabilidade de tensão e desequilíbrio, afetam a eficiência do equipamento elétrico. Para apoiar o bom funcionamento do equipamento, a energia elétrica gerada deve ser de boa qualidade. Este estudo tem como objetivo examinar a qualidade da energia do navio do sistema elétrico AHTS (Anchor Handling Tug Supply). Esta pesquisa foi realizada pelo método quantitativo. Técnicas computacionais utilizadas pelo software de Distorção Harmônica Total (THD), que compartilha características e Espectroscopia de Impedância Eletroquímica (EIS). O resultado dessa análise indicou que o sistema elétrico no VM

[1] Presented on 3rd ICMET

INPOSH REGENT possui energia de qualidade muito boa dos sistemas utilitários durante a condição de caminho completo; no entanto, durante a manobra, houve um harmônico particularmente alto dos dispositivos não lineares usados como controle do motor, que desempenham um papel funcional. propulsão. Com base no resultado acima, pode-se concluir que, após a filtragem, para que a harmônica possa corrigir até o perímetro seguro do padrão ABS, o sistema é muito bom durante o local longo da manobra e a manobra no sistema DP.
Palavras-chave: Correção da qualidade de energia; Equipamentos de embarcação; Sistema de energia a bordo; Equipamentos de eficiência; Filtro harmônico.

Abstract

A number of power quality issues including electrical harmonics, poor power factor, and voltage instability and imbalance impact on the efficiency of electrical equipment. To support that equipment operates optimally, electrical power is generated must be have good quality. This study has a purpose to examine the power quality of electrical system AHTS (Anchor Handling Tug Supply) vessel. This research was done by quantitative method. Computational techniques used by the software of Total Harmonic Distortion (THD), which shares characteristics and Electrochemical Impedance Spectroscopy (EIS). The result of this analysis indicated that Electrical system in VM INPOSH REGENT have quality power very good of utility systems during full way condition, however during maneuver, there was a particularly high harmonic from non-linier devices used as motor control, which functional a role propulsion. Based on the result above, it can be concluded that after filtering so that harmonic can correct until perimeter secure ABS standard, system is very good during maneuver long site and maneuver on DP system.
Keywords: Power quality correction; Vessel equipments; Power system onboard; Efficiency equipments; Harmonic filter.

Resumen

Una serie de problemas de calidad de energía que incluyen armónicos eléctricos, factor de potencia deficiente e inestabilidad de voltaje e impacto de desequilibrio en la eficiencia de los equipos eléctricos. Para que el equipo funcione de manera óptima, la energía eléctrica que se genera debe ser de buena calidad. Este estudio tiene el propósito de examinar la calidad de la energía del buque del sistema eléctrico AHTS (Anchor Handling Tug Supply). Esta investigación se realizó por método cuantitativo. Técnicas computacionales utilizadas por el software de distorsión armónica total (THD), que comparte características y espectroscopía de

impedancia electroquímica (EIS). El resultado de este análisis indicó que el sistema eléctrico en VM INPOSH REGENT tiene una potencia de calidad muy buena de los sistemas de servicios públicos durante la condición de camino completo, sin embargo, durante la maniobra, hubo un armónico particularmente alto de los dispositivos no linier utilizados como control del motor, que desempeñaban un papel funcional propulsión. Basado en el resultado anterior, se puede concluir que después de filtrar para que el armónico pueda corregir hasta que el perímetro asegure el estándar ABS, el sistema es muy bueno durante la maniobra en sitios largos y en el sistema DP.
Palabras clave: Corrección de calidad de energia; Equipos de embarcación; Sistema de energía a bordo; Equipos de eficiência; Filtro de armónicos.

1. Introduction

Power quality refers to the ability of electrical equipment to consume the energy being supplied to it. A number of power quality issues usually included electrical harmonics, poor power factor, and voltage instability and imbalance impact on the efficiency of electrical equipment. This has several number of consequences included: higher energy usage and costs, higher maintenance costs, equipment instability and failure.

Power quality encompasses availability of supply, frequency and voltage magnitude as well as waveform characteristics of the power supply (Johnsons & Hassan, 2016). Power described as a good quality if the electricity supply is constant at acceptable, steady values of voltage and frequency; and has smooth sinusoidal waveform.

The poor quality power can cause an overheat of equipments, reduced capability of insulation resistance and cause low efficiency. Power systems causes changes of nominal values of supplied voltage which distort the waveform sinusoid, and that will affect frequency stability and degrade power quality.

The maritime technology has progressed considerably, one of shipping areas start from drive technology, navigation equipment, vessel equipment, system control, and power plan. Power quality refers to the ability of electrical equipment to consume the energy being supplied to it. A number of power quality issues including electrical harmonics, poor power factor, and voltage instability and imbalance impact on the efficiency of electrical equipment. To supporting that equipment operates optimally, electrical power is generated must be have good quality. However with that used equipment resulting harmonic distortion of distribution system, so that affects the quality of electrical power. The poor quality power is cause equipment over heat, reduced capability of insulation resistance and cause low efficiency. This paper was re-analyzed of power quality in distribution system with reference Total Harmonic Distortion (THD) ≤ 5%. If the study has a total distortion of harmonic more than the standard, it will attach harmonic filter to the system in the hope total harmonic distortion (THD) ≤ 5% so that the system has good power quality. Thus, this study tried to examine the power quality of electrical system aht vessel wheteher it fit the standard or not.

2. Methodology

This research was done by quantitative method. Quantitative Quantitative methods emphasize objective measurements by statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques (Muijs, 2012). In this case, computational techniques used by the software of Total Harmonic Distortion (THD), which shares characteristics and Electrochemical Impedance Spectroscopy (EIS). Both share the same experimental basics by different analysis of measurement data. Harmonics have frequencies that are integer multiples of the waveform’s fundamental frequency. For example, given a 60 Hz fundamental waveform, the 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, harmonic components will be at 120Hz, 180Hz, 240Hz and 300Hz respectively. Thus harmonic distortion is the degree to which a waveform deviates from its pure sinusoidal values as a result of the summation of all these harmonic elements.

3. Results

There are several forms of service which can be provided to the community; verbal language; body language; the atmosphere of the room; dexterity and speed; etc. One of the elements that becomes service material is data delivery and information. Clearly, the completeness and transparency are important factors in the delivery of those services. The land service is a service about information, because of what is being sold is a database in the office to be delivered, legitimized by the authorized officials then the community has certainty on the asset that is owned (Saptomo, 1995).

The main component of the ship electrical power system are Generator, Shaft Generator, Main Switch Board (MSB), Emergency Switch Board (ESB), Power cable lines and electric consumers. In configuration basic (Figure 3) as the energy sources three electric generating sets usually applied, sometimes shaft generator as well as turbo generator is also installed. The main switch board on board a ship is the central node of her electric power system. The MSB and ESB are considered together with protective system, switches as well as main bus bar.

The electric power consumers can be fed directly from the main switchboard or emergency switchboard and switchboards by the appropriately designed power cable lines. Since the power of some switched-on heavy energy consumers is comparable to that of the ship electrical power system the switch of tugged winch on always result in put into parallel operation of one or more generators. The fact is when generator start-up for parallel operation leads to the appearance of significant amount of harmonics caused by subtransient reactance of generator.

A. Harmonics definition

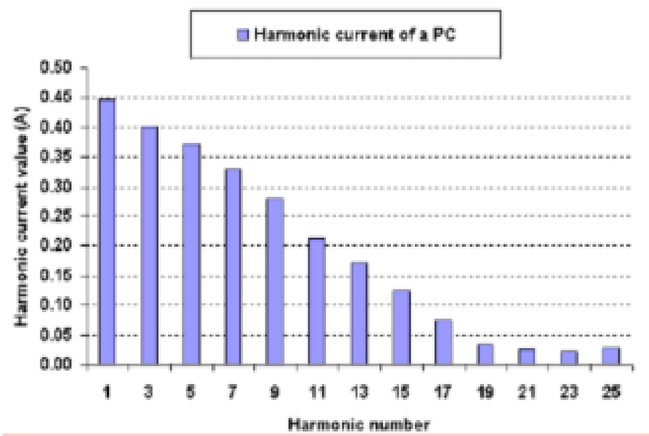
Harmonics defined as component sinusoidal wave from periodic or magnitude which frequency is an integer multiple of fundamental frequency, therefore it usually called as second harmonic (Kusuma, Semin, Zaman, & Satrio, 2018). (IEEE Std 100-1992 [B-14]) in power system with frequency 50 Hz/60 Hz, h is harmonic component as followed:

$$h = n \times 50Hz \quad (1)$$

$$h = n \times 60Hz \quad (2)$$

The amplitude of each harmonic can be described in curve called harmonic spectrum. Waveform can be presented in frequency region as shown figure below.

Figure 1. Harmonic Spectrum.



Source : Mesas, Sainz, & Sala (2015)

B. Harmonic distortion

Harmonics in voltage and current waveform are frequency components that are integer multiples of power system frequency. Harmonics are produced by non-linier load, which flow through power system impedances produce distortion in voltage waveform, that effects to power system. The general use any type of converters in marine application, such as main propulsion, thruster, compressor an pumps, has increased in such a way that the non-linier loading in current merchant and navy vessels can reach up to 80% of the onboard generation capacity (Borguet, Guerin, & Le, 2003).

The effect of harmonic distortion on equipment is well known. It produce additional losses in rotating electric machinery, transformers, cable, resonance effect in the power system, malfunctionof measurement and control equipment, malfunction of protective device or interference with electronic equipment, also communication and navigation equipment (Prasetyadi, Wibowo, & Penangsang, 2012).

Table 1. Max Voltage Distortion under all operation for shipboard.

	IEC	IEEE	DNV	ABV	LRS
Total harmonic distortion	5%	5%	5%	5%	8%
Single harmonic	3%	3%	3%	3%	1.5%

Source: own study

In both cases of harmonic disortion and single harmonic. higher limitations, up to 10% limit are allowed in dedicated system, such as dedicated propulsion switchboards, if all consumers and distribution equipment subject increased to distortion level is certified to withstand those harmonic distortion levels. Most of classification societies have adopted voltage distortion harmonic similar to DNV and ABS. in contrast, LRS uses THD limit of 8% of fundamental voltage at switchboard or section board, measured for harmonics up to 50 order, however establishes a strict limit only 1.5% for any individual voltage harmonic above 25^{th} order. Table 1 summarized the limits of voltage harmonic distortion under all operating condition for shipboard electrical insulations of the international organizations and the marine classification societies.

C. Asses a power quality on ships

A definition of power quality in IEEE Std 1159-1995, give description: “the term of power quality refersto a wide variety of electromagnetic phenomena that characterize the power system. In this context, electric power quality in ships system describe by the set of parameter characterizing process of generation distribution, utilization of electric energy in all operation. Power quality has a parameters cover two aspect (Janusz, 2014).

a. Parameter of voltage and current in all the points of the analyzed system.Parameter describing a risk of loss of power quality supply continues.

The first Parameters are coefficient of rms voltage value and its frequency deviations, coefficient of voltage asymmetry and coefficient characterizing the shape of voltage and current waveform, it is mean characterizing their distortion of supply voltage from sinusoidal wave. The second Parameters are related to correct distribution of active and reactive loads among generating sets working in parallel. The purposes of their control is to avoid blackout phenomenon, it is obtain a result of apparent overloading of ship power station.

D. Harmonic compensation

Generally, Single tuned filter is a series RLC (Reactor, Inductor, Capacitor) circuit tuned to a single harmonics frequency provides a low harmonic impedance characteristic. (Young & Hanju, 2011) Its total impedance is given by:

$$Zn = Rn + j\,(\acute{\omega}Ln - 1/\acute{\omega}Cn) \qquad (3)$$

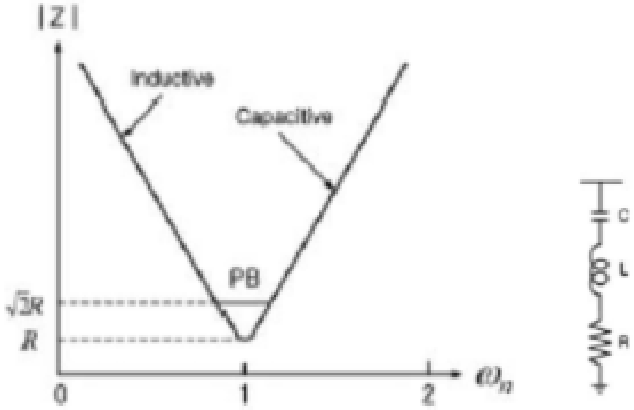
At resonance frequency $\acute{\omega}Ln = 1/\acute{\omega}Cn$, then $Zn = Rn$

An ideal single-tuned filter should be tuned on a frequency that makes its inductive and capacitive reactance equal (Arrilaga & Watson, 2003). Filter with low quality factor (Q) is sharply tuned to one of the lower harmonic frequency, and typical value between a range of 30 to 60. The filter with high Q typically in region of 0.5-5.5 has low impedance over a wide range of frequency.

$$Q = X/R \qquad (4)$$

(a) Impedance characteristic
(b) RLC Series

Figure 2. Impedance Characteristic Curve versus Frequency.



Source : Impedance vs Frequency Study

In Figure 2, The filter pass Band (PB) define as being bounded by frequencies which the filter reactance is equal to its resistance, the impedance angle is 45 and the magnitude is √2R. Relationship between quality factor and pass band can be descreibed as below:

$$Q = \acute{\omega} / PB \qquad (5)$$

E. Onboard electrical system

System distribution electric power in VM WINPOSH REGENT is typical network, therefore very substation connecting of all loads group. It has two generating electric kinds of diesel generator (DG) each capacity 425 kW and other power plane are shaft generator (SG) each capacity 1200 kW. VM WINPOSH REGENT is supplied with dynamic positioning system technology (DP2) so that all plants will automatically supply power to the main switch board (MSB) if there is a disturbance one power plan, and can also work individually for additional maneuvering by the standard M3.

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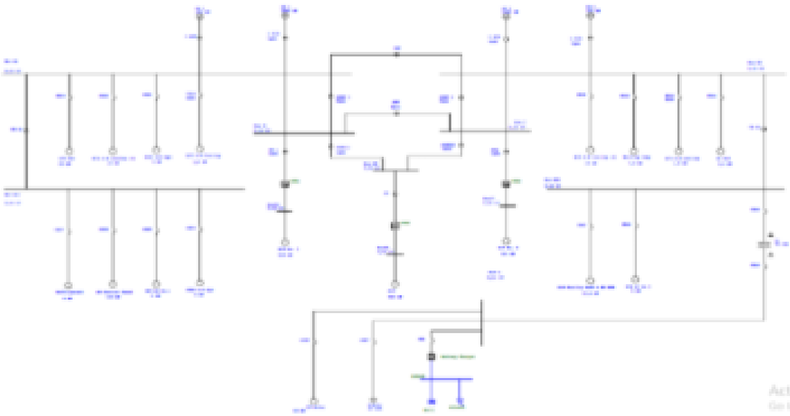
Figure 3. One Line Diagram VM WINPOSH REGENT.



Source: Authors.

Based on Figure 3 above, it is showed that electric system simulation of vessel, which is operation on voltage 440 volt, frequency 60 Hz, use fourth wire, IT (Grounding) without neutral and doing simulation for analyses power quality. It is cover two scenarios are when full way and maneuvering.

F. Electric system simulation

1) Simulation when full away

From the result of simulated drill, then there is a total harmonic distortion voltage (THDV) on every bus bar.

Table 2. Harmonic Load Flow – Full Away.

BUS ID	**Voltage** (kV)	**Fund** (%)	**THDV** (%)
BUS A1	0.44	100	0.63
BUS A2	0.44	100	0.63
BUS AH	0.44	100	0.63
BUS A21	0.44	100	0.63
BUS D	0.44	98.16	1.59

Source: own study.

Table 2 showed THDV value on every bus that is function for distribution electric. When full way condition the all equipment electric is supplied from one generator only connected of Bus A1, this condition does not require Bow Thruster (BT) and Stern Thruster (ST) so that bus B and Bus C not connected.

2) Simulation when maneuvering

This conditions, of appliances full way continue to be used with the Bow Thruster and Stern Thruster additional to the Shaft Generator (SG 1&2) supply independent link to buses B and Bus C, result from simulation in following table:

Table 3. Harmonic Load Flow – Maneuvering.

BUS ID	Voltage (kV)	**Fund** (%)	**THDV** (%)
BUS A1	0.44	100	0.63
BUS A2	0.44	100	0.63
BUS AH	0.44	100	0.63
BUS A21	0.44	100	0.63
BUS B	0.44	100	16.44
BUS BC	0.44	100	16.44
BUS D	0.44	98.16	1.59

Source : own study.

Table 3 shows that there is a THDV that exceeds standard ABS 5% on Bus B and Bus BS by 16. 44%, so a filter needs to reduce THDV on the Bus BC.

3) Planning and filter design

Recapitulation results on 16.44% of variable drive (VFD) and stern thruster (ST) as resupplied with SG No1. To plan the filter and conduct harmonic analysis on BC Bus.

Figure 4 below shows that highest harmonic obtained on the 5^{th} and 7^{th} of order. To reduce the harmonic, it is rationalized using single tuned filter on the $5^{th}$and 7^{th} order. By equation, it will be parameters voltage a phase at work voltage 0.25 kV to design a single tuned filter that will eventually be linked to the BC bus delta 3 phases and grounding.

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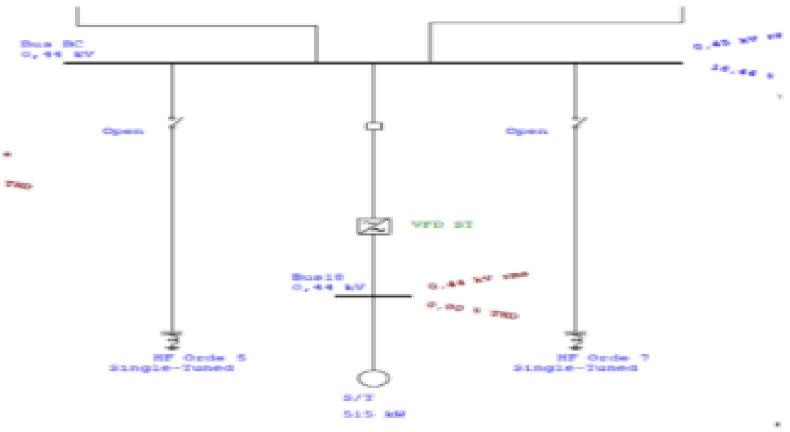
Figure 4. Assembly Single Tunned Filter on BC Bus.



Source: Authors.

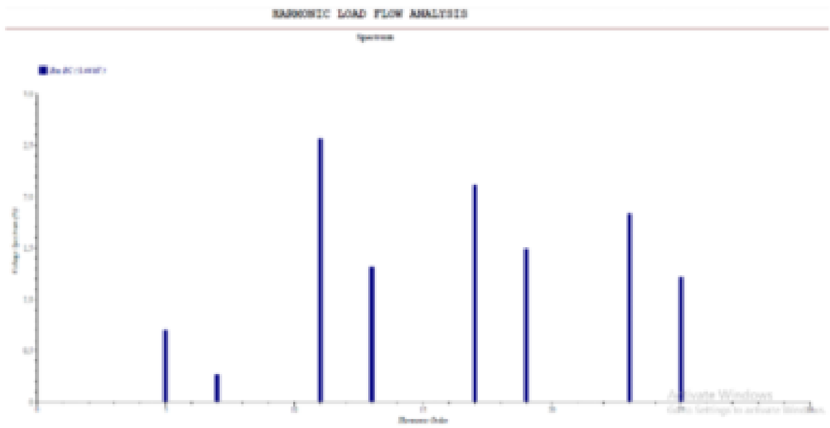
The assembly filter connecting on BC Bus purpose to keep stability THDV if Stern Thruster (ST) connecting with Bow Thruster (BT) No.2 supplied by SG No.2 if SG No.1 fails when maneuvering. With additional filter that parameter in table below:

Table 4. Tunning & Parameter Factor Q40.

Order	**5th**	**7th**
f_n (Hz)	300	420
Tunning (Hz)	297	415
C (μF)	424.7	424.7
L (H)	0.00067	0.000346
XL (Ω)	0.252	0.13
R (Ω)	0.0063	0.00325

Source: Authors.

Figure 5. Harmonic Spectrum after filtered – Maneuver Condition.



Source: Authors.

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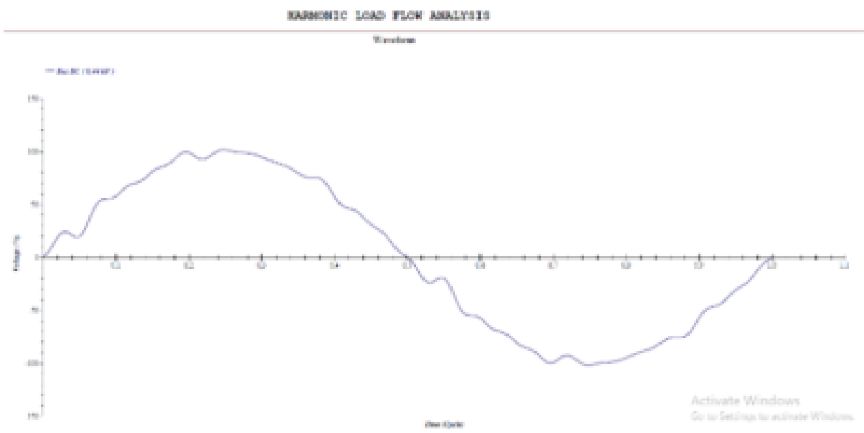
Figure 6. Harmonic Wave After Filtered – Maneuver Condition.



Source: Authors.

Figure 6 shows the result of spectrum and waveform after filtered harmonic in 5th and 7th order with THDV is 4.52%. It is mean that filter can reduce harmonics until perimeter secure related to ABS standard.

4. Final Consideration

Electrical system in VM INPOSH REGENT have quality power very good of utility systems during full way condition, however during maneuver, there was a particularly high harmonic from non-linier devices used as motor control, which functional a role propulsion. Though working as an independent, however harmonic is high risk to other equipment connected mainly to shaft generator.

Based on the result above, it can be concluded that after filtering so that harmonic can correct until perimeter secure ABS standard, system is very good during maneuver long site and maneuver on DP system. With the assembly filter indirectly can also correct power factor on the Bus which it is fitted.

Thus, power quality of electronical system AHTS (Anchor Handling Tug Supply) will be good if it in a good condition and obtain a correct maneuver system.

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