Designing Passive Filters to Reduce Harmonics on Energy Saving Lamp (LHE) Loads

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Abstract *— LHE lights produce harmonics that disrupt the electric power system. The harmonic effect generated is caused by the use of non-linear electrical electronic components. Non-linear loads produce a distorted capital wave current and result in the formation of waves at a frequency of round multiples of the fundamental frequency. Based on the negative impact caused by LHE lamps, it is necessary to conduct research by designing filters to reduce the THDi percentage generated by the LHE load. The study was conducted by installing a RC low pass filter on the LHE load. The research was conducted by measuring to obtain data from four (4) LHE lamps which were measured using a harmonic measuring instrument. The data obtained in the analysis to find out the THDi size that must be adjusted to the IEEE Standard. Research by using a low pass RC filter with the results of the measurement of the first light (1) the THDi percentage obtained is 60.22% decreased to 4.33%, the second lamp (2) obtained the THDi percentage from 84.44% decreased to 3.66%, third lamp (3) obtained THDi percentage from 72.20% decreased to 3.48%, and fourth lamp (4) obtained THDi percentage from 62.40% decreased to 4.43%. The harmonic reduction results that occurred were quite significant ranging from 55.89% to 80.78%. This low pass RC harmonic filter design has succeeded in reducing Total Harmonic Distortion according to the frequency set (cut off frequency) of 150 Hz in order 3.*

Keywords *— Low Pass RC Filter, Harmonics.*

I. INTRODUCTION

The burden of LHE lamps is most widely used by the community as a substitute for lighting at night. LHE lights have a cheap price and attract attention with the consumption of low electrical energy has been able to produce sufficiently bright light. LHE lamps have economical advantages in electricity energy consumption which also has harmonic losses. The harmonic effect is caused by the use of non-linear electrical electronic components. Nonlinear components that are used for switching such as thyristors, transistors, diodes, capacitors, and inductors, can produce distorted currents that are synodally waves. Distortion that occurs due to non-linear disturbances that exist in voltage and current waves, thus forming waves at the frequency of round multiples of the fundamental frequency. Distortion waves due to nonlinear loads will affect the electric power system. The electric power system will experience difficulties and cause heat to the transpator. Heat on the transpomator can cause disruption of the distribution of electrical energy to the user.

This research was carried out by designing filters to reduce the percentage of THD generated by LHE loads. The research design was carried out by installing an RC low pass filter on the LHE load.

A. *Problem Formulation*:

From the above description, the formulation of the problem can be made as follows:

1. How to design a RC Low Pass Filter to Reduce LHE Harmonics?
2. What is the Result of the Energy Lamp Measurement After Installing the Low Pass RC Filter?

B. *How to do research*,

1. Prepare the RC low pass filter plan,
2. Conduct research by installing an RC low pass filter on the lamp
3. Measuring the load from the lamp as research material to be able to find out THDi before installing the RC low pass filter,
4. Measuring the load from the lamp as research material to be able to find out THD after installing the RC low pass filter,
5. Conduct analysis to determine the difference in results before and after the RC low pass filter is installed
6. Make conclusions.

II. MATERIAL AND METHODS

The material in this research is the LHE lamp in the market, which is 2x20 Watt, 2x18 Watt, and 1x35 Watt and RC Low Pass Filter.

The method of data collection is done by analyzing data and measuring THDi and THDv for each energy saving lamp brand (LHE). The Simulink Matlab results data that hase been compared, are grouped for analysis.

III. RESULTS AND DISCUSSION

In determining the value of resistor and capacitor components to be used in fiter, measurements must be made on the load of the lamp collecting to obtain the data. The data obtained is used as a reference in determining the value of each component. Data from the Energy Saving Lamp (LHE) measurements before the RC low pass filter is installed can be seen in Tables 3.1 and Table 3.2 are data from individual harmonic measurements before the RC low pass filter is installed:

TABLE 3.1
RESULTS OF LAMP MEASUREMENTS BEFORE A LOW PASSRC FILTER IS INSTALLED

No	Brand Lighting	Voltage (V)	Current (A)	Power Active (W)	Power Real (VA)	Power Reactive (Var)	Cos φ	THD-I (%)
1	OMI	227	0.096	15.01	22	11.39	0.6824	60.22
2	FANOS	227.6	0.3528	47.58	80.29	38.72	0.5926	84.44
3	PHILIPS	225.4	0.2428	35.02	54.73	27.25	0.6399	72.20
4	MAXTRON	227.6	0.0681	10.15	15.5	8.365	0.6546	62.40

TABLE 3.2
INDIVIDUAL HARMONIC MEASUREMENT DATA BEFORE THE RC LOW PASS FILTER IS INSTALLED.

No	Brand Lighting	HARMONIC CURRENT (%)				THD-I (%)
		3	5	7	9	
1	OMI	48.17	24.09	24.09	12.05	60.22
2	FANOS	59.36	37.1	33.39	33.39	84.44
3	PHILIPS	55.88	30.48	30.48	15.24	72.20
4	MAXTRON	51.29	34.62	0	0	62.40

The data in table 3.1 shows the measurement data with numbers from 0.081A to 0.3528 A. Measurement of readable power 10.10 W to 47.58 W and power factors ranging from 0.5926 to 0.6824. Data from the measurement of energy saving lamps is still not efficient because the power factor is still low. The measurement data in Table 3.2 can reveal Large Total Harmonic Distortion (THDi) for the flow produced by energy saving lamps ranging from 60.22% to 84.44%. Individual harmonic measurements at number 3 can be achieved from 48.17% to 59.36% from the base and in the 9th order harmonics are 12.05% to 33.39%. The third harmonic value is quite high with a frequency ranging from 150 Hz, and to reduce the cut-off frequency from the frequency of 150 Hz. The harmonic spectrum can be seen with the help of simulink matlab soft ware image 3.1.

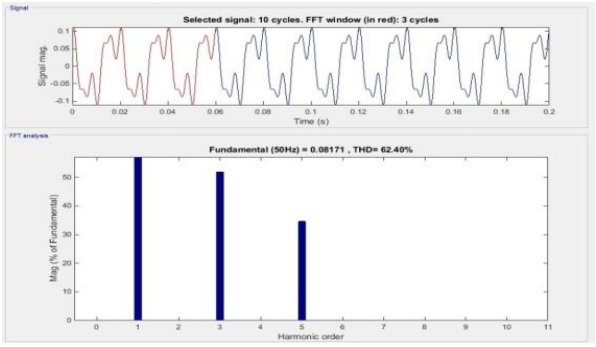

Fig. 3.1: The harmonic spectrum of the lhe before the rc low pass filter is installed

A. Design of Low Pass RC Filters to Reduce Harmonics of LHE

Based on the results of measurements that have been made on the sample of four Energy Saving Lamps, the level of harmonic distortion caused by the use of LHE is quite high with an average THD reaching 69.81%. The filter is designed to be able to reduce harmonics with components consisting of resistors and capacitors. Filters are expected to be able to reduce harmonics that are above the cut-off frequency and pass frequencies below the frequency.

In calculating the value of resistors and capacitors used, first determined the cut-off value of 150 Hz, then calculated each value of the resistor and capacitor components using the following equation.

$$f_c = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}} \quad \text{.....1}$$

Looking for the value of fc by determining the value of components R1 = 1k2, R2 = 1k17, C1 = 4µF, and C2 = 200 nF using equation 1, then

$$f_c = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}} = \frac{1}{2\pi\sqrt{1200x\,4x10^{-6}x1170x2x\,10^{-7}}}$$

= 150,2 Hz

The calculation results using equation 1, the magnitude of fc = 150.2 Hz. To calculate the value of each component in another lamp filter the steps are the same.

B. LHE Lamp Measurement Results After Installing the Low Pass RC Filter

Results of measurement of electrical variables from energy saving lamp samples consisting of voltage (V), current (I), active power (P), Reactive Power (Q), Real Power (S), power factor (cosφ), and Total Distortion Harmonic (THDi) can be seen in table 3.3. The measurement results of individual harmonic currents for each energy saving lamp on the 3rd, 5th, 7th and 9th harmonics are shown in table 3.4.

TABLE 3.3
DATA MEASUREMENT RESULTS AFTER INSTALLING AN RC LOW PASS FILTER

No	Brand Lighting	Voltage (V)	Current (A)	Power Active (W)	Power Real (VA)	Power Reactive (Var)	Cos φ	THD-I (%)
1	OMI	227	0.1277	24.25	29	15.85	0.863	4.33
2	FANOS	227.6	0.1613	35.41	36.72	9.616	0.9644	3.66
3	PHILIPS	225.4	0.2238	46.11	50.44	20.38	0.9141	3.48
4	MAXTRON	227.6	0.122	22.04	27.76	16.84	0.7938	4.43

TABLE 3.4
DATA FROM INDUVIDUAL HARMONIC MEASUREMENTS AFTER THE LOW PASSRC FILTER IS INSTALLED

No	BRAND LIGHTING	HARMONIC CURRENT (%)				THD-I (%)
		3	5	7	9	
1	OMI	4.05	1.23	0.86	0.33	4.33
2	FANOS	3.29	1.24	0.8	0.62	3.66
3	PHILIPS	3.22	1.06	0.76	0.29	3.48
4	MAXTRON	4.11	1.65	0	0	4.43

The measurement results of electricity and harmonic percentages in each energy-saving lamp circuit after the RC low pass filter is installed, changes in Power measurement from 15.05W to 24.25W. The current rises from 0.096A to 0.1277A, the changes in power real from 22 VA to 29 VA, the reactive power from 11.39 Var to 15.85 Var. Power factor from 0.682 to 0.863. There is a sufficient decrease in the percentage of harmonics for the total harmonic current distortion (THDi) which is from 62.22% to 4.33%, whereas for each harmonic it can be seen in table 3.4 and Figure 3.2 on the 3rd order harmonics from 48.17% to 4.05%. Order 9 harmonics from 12.05% to 0.33%.

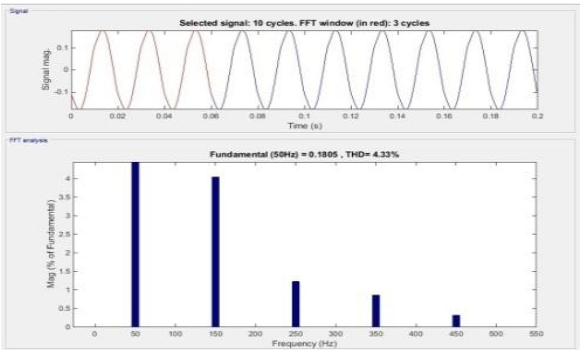

Fig. 3.2: The harmonic spectrum of the LHE OMI 2 x 20W after the RCfilter low pass is installed

The measurement results are shown in table 3.3, then compared with the IEEE standard 519-2014.

TABLE 3.5.
MEASUREMENT DATA ON FILTERS ARE COMPARED WITH IEEE 519-2014 STANDARDS

No.	Brand Lighting	THDi Standart IEEE 519-2014	THDi Value Meansurement	Descriptions
1	OMI	5%	4,33%	Matching
2	FANOS	5%	3,66%	Matching
3	PHILIPS	5%	3,48%	Matching
4	MAXTRON	5%	4,43%	Matching

Table 3.5 shows the results of the use of Low Pass RC Filters that are able to reduce harmonics generated by the LHE lamp load and are in accordance with IEEE 519-2014 standards THD value is not more than 5%.
The large low pass RC filter designed is able to reduce the total harmonic distortion generated by each energy saving lamp and calculate the amount of damping that can be done by the filter.

1. Data first lamp we are enter in the following equation:

$$THD = \frac{\sqrt{I_3^2 + I_5^2 + I_7^2 + I_9^2}}{I_1}$$

$$THD = \frac{\sqrt{0{,}0073^2 + 0{,}0022^2 + 0{,}0016^2 + 0{,}0006^2}}{0{,}1805}$$

$$THD = \frac{\sqrt{0{,}007819}}{0{,}1805}$$

$$THD = 4{,}33\%.$$

THD value from the calculation with the measurement THD value obtained a is same 4.33%. For the THD reduction percentage value, the current in the filter is,

$$THD = THD_{(before)} - THD_{(afte)}$$

$$THD = 62{,}40\% - 4{,}33\%$$

$$THD = 57{,}97\ \%$$

So the THDi value that can be reduced after installing the RC low pass filter is 57.97% at harmonic frequencies ranging from 150 Hz upwards and at frequencies below 150 Hz, is passed (according to the frequency specified in the filter).

Data from the damping of each LHE lamp is shown in table 3.6 below.

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TABLE 3.6.
DAMPING DATA ON EACH LHE LAMP.

No	Brand Lighting	Standart IEEE 519-2014	THDi Before Apply Passive Filter	THDi After Apply Passive Filter	Reduction THDi
1	OMI	5%	60,22%	4,33%	55,89%
2	FANOS	5%	84,44%	3,66%	80,78%
3	PHILIPS	5%	72,20%	3,48%	68,71%
4	MAXTRON	5%	62,40%	4,43%	57,97%

Table 3.6 displays the results data for each LHE lamp after using the RC Fillter Low Pass. In the first lamp the current harmonic reduction was 55.89%, the second lamp was 80.78%, the second lamp was 68.71%, and the fourth lamp was 57.97%. The filter that has been designed has succeeded in reducing the harmonics generated by the LHE load. More details can be seen in the following graph image.

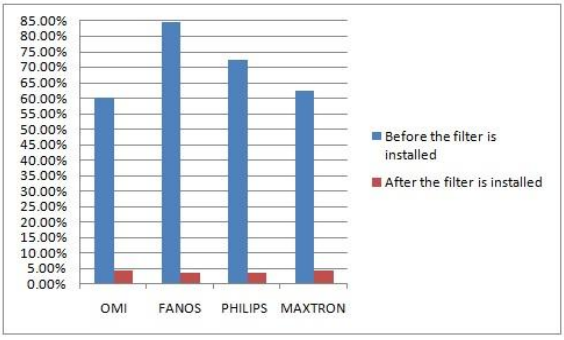

Fig 3.3: Graphs are placed before and after the RC low-pass filter is installed

UPDATE ON RESEARCH

The Low Pass RC Filter design can be developed to reduce harmonics in other loads by recalculating as needed. This design can be installed on the another lamp to reduce THD.

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IV. CONCLUSIONS

From the simulink results that have been done, the conclusions can be drawn as follows:

Before the RC low pass filter is installed, the measurement results show the Total Harmonic Distortion Current (THDi) on 4 energy saving lamp samples between 60.22% to 84.44%. After installing a low pass, RC filter, the measurement results show the Total Harmonic Distortion Current (THDi) on 4 energy saving lamp samples between 3.66% to 4.43%. This low pass RC harmonic filter design has succeeded in reducing Total Harmonic Distortion according to the frequency set (cut off frequency) of 150 Hz in order 3.

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