Effect of LC Filter In Reducing Harmonic Current in NVIS 7017 Three-Phase Synchronous Generator Lab Trainer

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Abstract. The electrical energy conversion laboratory located in the electrical engineering workshop environment is a room for students majoring in electrical engineering education at Universitas Negeri Medan for electrical machinery practice activities. NV7017 Three-Phase Synchronous Generator Lab Trainer is used to practice electrical machines for students. From the observation results, this trainer contains a total harmonic distortion current of 82.1%. After research using an LC filter, it can reduce the content of harmonic currents that appear to be 14.28%. The results obtained are good but according to the IEEE 519 -2014 standard for $I_{SC}/I_L = 46.77$ for a 220-volt system voltage, the permissible third-order individual harmonic distortion current (IHDi) is 7%, while the research results obtained are 12.65%. So it is necessary to conduct further research in order to determine other types of harmonic filters that can reduce harmonic currents according to IEEE 519 - 2014 standards.

Keywords: LC Filter, Harmonics, Synchronous Generator.

1 Introduction

Electrical energy has now become a basic need for both household and industrial users. Some of the most important electrical components on the generator side are generators. This generator then produces electrical energy by converting mechanical energy into electrical energy. Abdullah et al's research results show that synchronous generators cause serious power quality problems at the neutral point of the distribution system [1].

Before the widespread use of electronic equipment, harmonics were found to cause various problems in electrical systems and AC equipment, especially generators [2]. The voltage produced by the generator is not purely sinusoidal because it has been distorted by nonlinear loads with different voltage and current harmonic contents [3].

Synchronous generators also cause interference in telephone networks by inducing triple voltage harmonics in telephone networks [4]. Synchronous generators also generate heat for the neutral ground resistance of the generator when used in parallel with a distribution network [5]. It was found that the third order harmonic current flowing into the neutral ground

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resistance of the generator originates from the synchronous generator itself. Harmonic currents in the distribution network are opposite to the load flow, so that mechanical vibrations can occur on the generator shaft and electrical torque can also occur, causing a lot of heat to be lost in the stator windings.

Triple (triple) harmonic currents are 3rd, 9th, 15th order currents, etc. In balanced conditions, triple harmonic currents will increase at the neutral point. So, the magnitude of the triple harmonic current at the neutral point is tripled in three-phase current. Triple harmonic currents are zero-sequence harmonic currents returning to neutral. When the generator is connected to the grid, the triple harmonic current becomes high because the power supply experiences a short circuit or low zero-sequence impedance to the triple harmonic current [6].

Triple harmonic currents cause an overload on the neutral conductor or bus, causing a significant voltage drop between neutral and ground. In a star-delta connection transformer, the star secondary neutral conductor carries three harmonic currents. To prevent this, triple harmonic currents circulate in the delta primary winding, which can cause overheating and transformer failure. Star-connected power capacitors can be damaged by high triple harmonic currents during parallel resonance [7]. In some cases, triple harmonic currents have caused zero ground resistance (NGR) failures [8].

From the research that has been carried out, it is proven that the LC filter is successful in reducing current harmonics [9]. The NVIS 7017 three-phase synchronous generator lab trainer is practical equipment for electrical machines in the electrical energy conversion laboratory. Practice using the NVIS 7017 three-phase synchronous generator lab trainer [10]. After observing the current harmonic content in the NVIS 7017 three-phase synchronous generator lab trainer, it was found that the total harmonic distortion current reached 82.1%. Therefore, researchers are interested in conducting research on the effect of LC filters in reducing harmonic currents in the NVIS 7017 three-phase synchronous generator lab trainer.

2 Method

2.1 Implementation of Research

This research was carried out in the Electrical Engineering workshop of the Energy Conversion Laboratory on the NV7017 Three Phase Synchronous Generator Lab Trainer load. The first thing to do is take total harmonic current distortion data when the NV7017 Three Phase Synchronous Generator Lab Trainer is operated and then measure it using a Fluke 437 power quality analyzer to obtain the variables of voltage, current, frequency, THD and so on. After taking measurements, the next step is to model a single tuned passive filter using software tools.

The variable quantities that have been measured are entered into the modeling using software tools to match the measurement results, then the single tuned passive filter modeling is installed in the simulation to calculate how much the LC filter can reduce the harmonics that appear. The hope is that after installing a LC filter, the total harmonic current distortion that appears can be reduced in accordance with the standards permitted by IEEE 519 – 2014.

2.2 Flowchart of Research

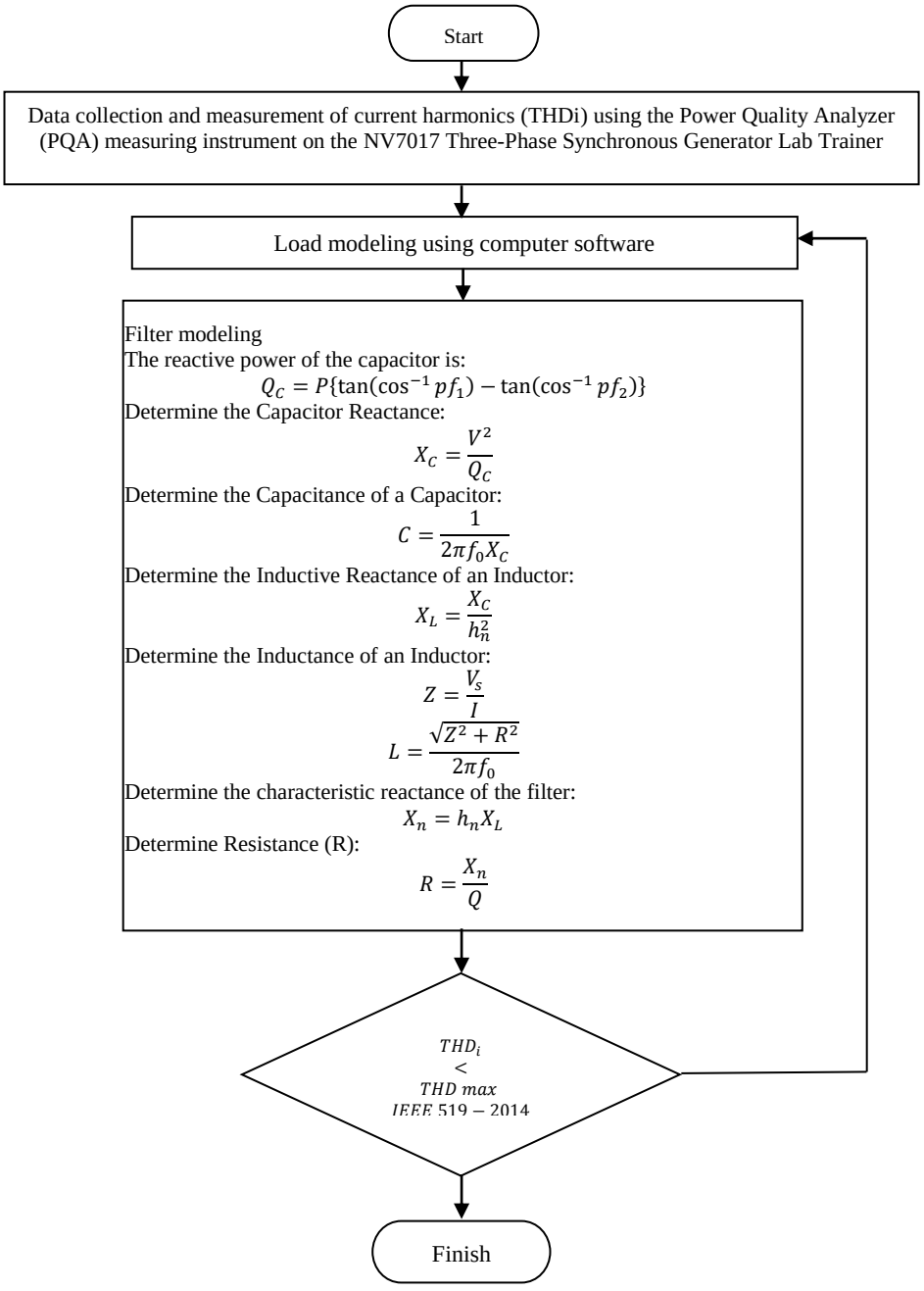

Fig. 1. Flowchart of reasearch

3 Results and Discussion

3.1 Harmonic measurements

After measuring current harmonics on the NVIS 7017 three-phase synchronous generator trainer equipment, data was obtained as in the following Table 1.

Table 1. Harmonic measurements

Harmonic order	IHD_i (%)	Harmonic order	IHD_i	THD_i (%)
3	41,52	27	4,34	82,08
5	33,63	29	3,38	
7	29,93	31	3,06	
9	27,68	33	3,06	
11	24,94	35	3,22	
13	22,21	37	3,22	
15	18,99	39	3,22	
17	16,09	41	2,90	
19	13,19	43	2,41	
21	10,46	45	2,09	
23	8,05	47	1,61	
25	5,95	49	1,29	

3.2 Circuit simulation

In the simulation circuit, individual harmonic distortion currents from the third order to the 49th order are modeled according to the measurement results. In this modeling, an LC filter was also installed to reduce the harmonics that appear in the NVIS 7017 three-phase synchronous generator trainer. The simulation circuit can be seen in the following fig 2.

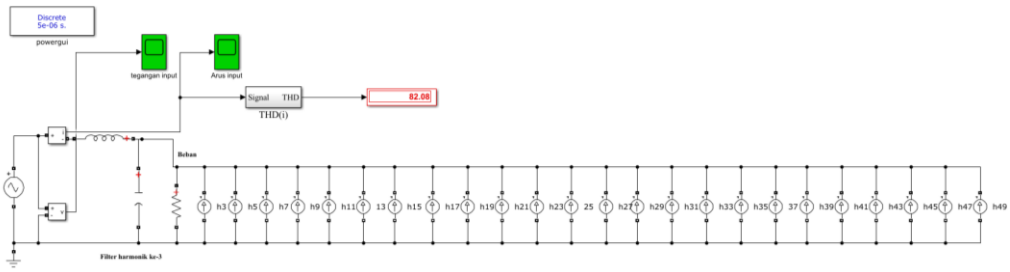

Fig. 2. Circuit simulation with LC filter

From the simulation results using an LC filter to reduce current harmonics in the NVIS 7017 three-phase synchronous generator trainer, the total harmonic distortion was reduced to 14.28%, complete data can be seen in Table 2, the waveforms before and after installing the filter can be seen in Fig 3 and Fig 4. The harmonic spectrum before and after installing the filter can be seen in Fig 5 and Fig 6.

Table 2. Comparison of current harmonics before and after installing the filter

Harmonic order	IHD_i before filter (%)	IHD_i after filter (%)	THD_i before filter(%)	THD_i after filter(%)
3	41,52	12,65		
5	33,63	5,40		
7	29,93	2,96		
9	27,68	1,84		
11	24,94	1,18		
13	22,21	0,78		
15	18,99	0,52		
17	16,09	0,35		
19	13,19	0,23		
21	10,46	0,15		
23	8,05	0,10		
25	5,95	0,06	82,08	14,28
27	4,34	0,04		
29	3,38	0,03		
31	3,06	0,02		
33	3,06	0,02		
35	3,22	0,02		
37	3,22	0,02		
39	3,22	0,01		
41	2,9	0,01		
43	2,41	0,01		
45	2,09	0,01		
47	1,61	0,00		
49	1,29	0,00		

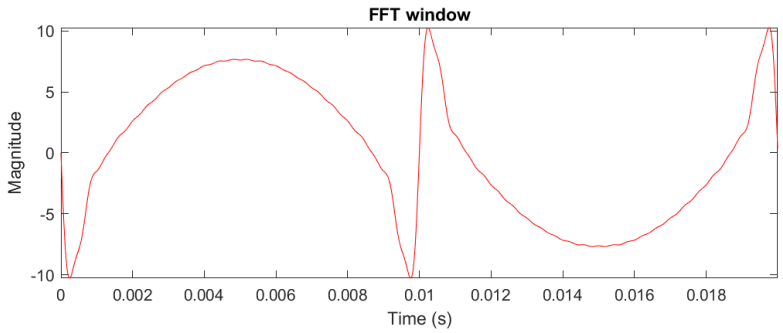

Fig. 3. Current wave before installing the filter

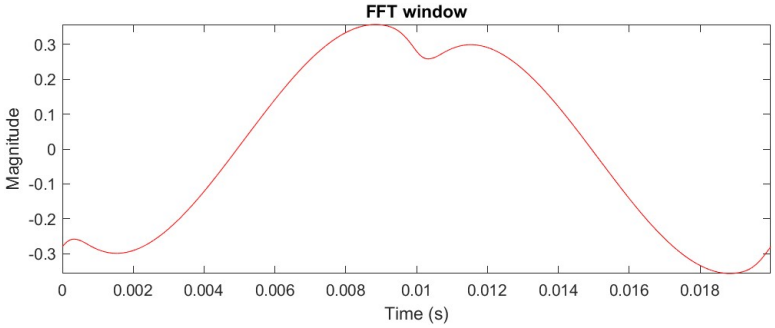

Fig. 4. Current wave after installing the filter

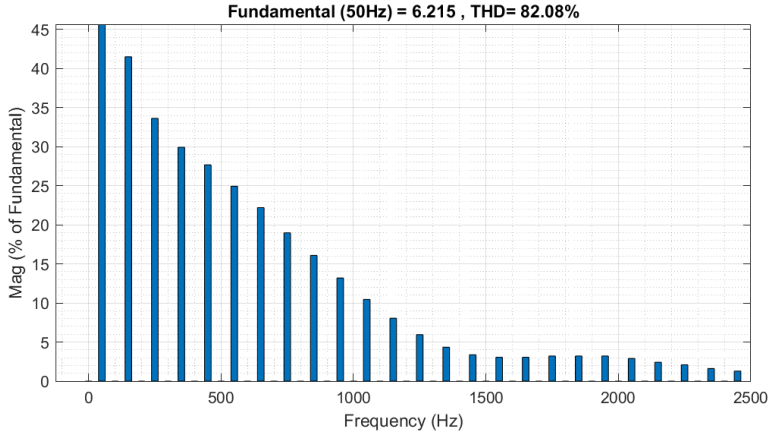

Fig. 5. The harmonic spectrum before installing LC filter

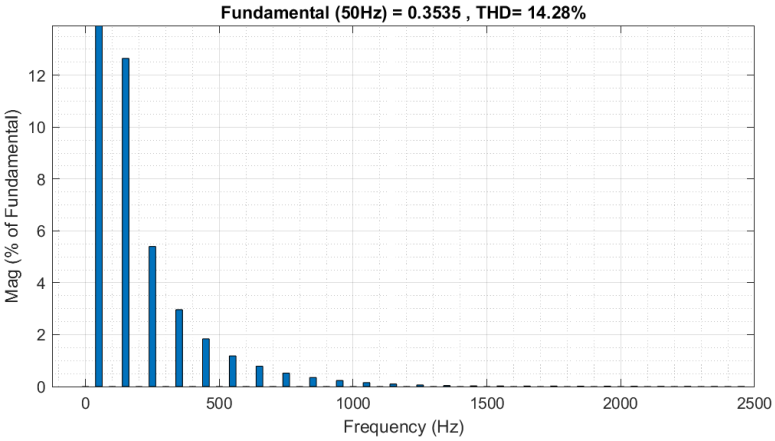

Fig. 6. The harmonic spectrum after installing LC filter

4 Conclusion

The LC filter is very effective in reducing current harmonics caused by the NVIS 7017 three-phase synchronous generator trainer. From the research data it can be concluded that all individual harmonic distortion currents from the third order to the forty-ninth order have been successfully reduced significantly and this result has also been achieved. complies with IEEE 519 -2014 standards.

Acknowledgments

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