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Performance Analysis of Integration between Zero Passing Transformer and LC Filter to Minimize For Zero-Sequence Current Harmonics In Neutral Conductor

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Abstr**act:** This paper is described the technique to minimize the zero-sequence current harmonics in neutral conductor of three phase four wire distribution systems are generated by nonlinear load. The dominant current for zero-sequence current harmonics in neutral conductor is 3rd harmonic where can be minimized by using star delta transformer. The star delta transformer is parallel connected to the nonlinear load. Based on this approached, not all zero-sequence current harmonics can be minimized by zero passing transformers. It is requiring an additional LC filter circuit to further reduce on 9th harmonic, 15th harmonic, 21st harmonic and etc. in neutral conductor. The conformity of minimization approached is demonstrated practically.

Keywords: Zero-sequence current, harmonics, star delta transformer, zero passing transformer and LC filter

1.0 INTRODUCTION

In the past 48 years, the explosion of solid-state electronic technology had been increased drastically. Due to that the harmonics problems are considered seriously in the electrical power system. These solid state electronic devises are one of the sources of harmonics [1]. In theoretically, the voltage and currents are almost in sinusoidal waveforms. However, due too many of electronic components are used to build in electrical and electronics equipment's, this waveform will be deviated from the perfect sinusoids. The waveform deviations can be represented by harmonic components which having a frequency that is an integral multiple of the fundamental frequency. Through oscilloscope the waveform looks like distorted, not smooth and many noises. It means that for pure sinusoids waveform has no distortion and very low total harmonic distortion compare with deviate waveforms. The deviate waveforms were consisted with high distortion and high total harmonic distortion.

Based on studies, the three phase power lines were connected with solid state devices shows that the waveforms was contents of 3rd, 5th, 7th , 9th and etc. harmonics order. However, on three phase four wire electrical distribution systems shows that the neutral current in neutral line is overloaded with neutral current even though the systems is balanced systems. In theoretically the neutral current should be zero current. This neutral current is called excessive neutral current which is consisted of harmonic orders 3rd, 9th, 15th, 21st, 27th, 33rd and etc. These entire harmonic is called triplen current harmonics or zero-sequence current harmonics. All these phenomena were caused by solid state devices or nonlinear device [1,2]. Effect from this phenomena can caused the neutral line increase of wiring failure, transformer overheating and elevated of neutral potential [3]. An example was reported by Computer and Business Equipment Manufacturer Association (CBEMA). CBEMA recently reported that a shared neutral conductor in building may carry increased harmonic currents and result in wiring failures [4].

In order to minimize the zero sequence current harmonic in three phases four wire distribution systems by using zig-zag transformer [3] and alternative way with active power filter [5]**.** The zigzag transformer has very low zero sequence impedance so that the zero sequence current harmonics will be circulated in zigzag transformer. Meanwhile, active power filter using power electronics device includes control circuit to cancel zero-sequence current harmonics in the neutral line. This approach is

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very complicated and expensive compared with zigzag transformer.

In this paper described another methods which are using star delta transformer is proposed to reduce the zero-sequence current harmonics in three phase four wire distribution system. The experimental results are carried out in order to show the justification of proposed.

2.0 METHODS

The nonlinear load currents are possibilities were generated from non-sinusoidal generation of voltage, nonlinear devices used in the transportation of electrical energy especially from variable frequency drivers, uninterruptible power supplies and power electronic converters or others nonlinear load devices such as switch-mode power supplies and fluorescent light [6,7]. An example the voltage waveforms are generated from stepped up transformers are very close to sinusoidal and have little distortion. The transmission lines, cables and transformer are transportation devices which are quite linear in nature and cause little distortion to voltage or current waveforms.

A. Current distorted

Now days, many nonlinear loads as above mentioned will be linked to the three phase four wire systems consequently the whole system will be saturated with current harmonics. For the first, second and third phases will carry with harmonic orders 3rd, 5th, 7th, 9th, 15th and etc. However, the zero sequence current harmonics such as 3rd, 9th, 15th, 21st, 27th, 33rd and etc. will be added in neutral wire. Meanwhile, the positive sequence harmonic such as 1st, 7th, 13th etc. and negative sequence harmonic such as 1st, 7th, 13th etc. will be cancelled in neutral conductor. Therefore, the actual neutral current is lifted by zero sequence current harmonics and dominated by 3rd current harmonics.

B. Star-delta transformer

The star-delta transformer will be shunted to three phase four wire systems. This star-delta transformer has very low zero sequence current harmonic. Besides that this transformer has low impedance but high impedance for positive and negative sequence harmonic. Based on this criterion this transformer can be called as a zero passing transformer. The configuration for zero passing transformers is illustrated in Fig. 1

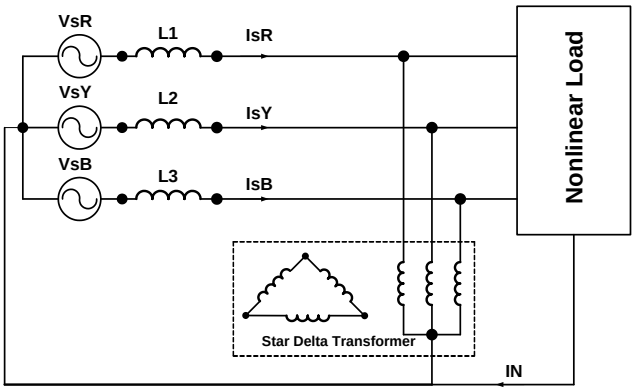

Fig. 1 Star delta transformer as a zero passing

The equivalent circuit for Fig. 1 is represented in Fig. 2.

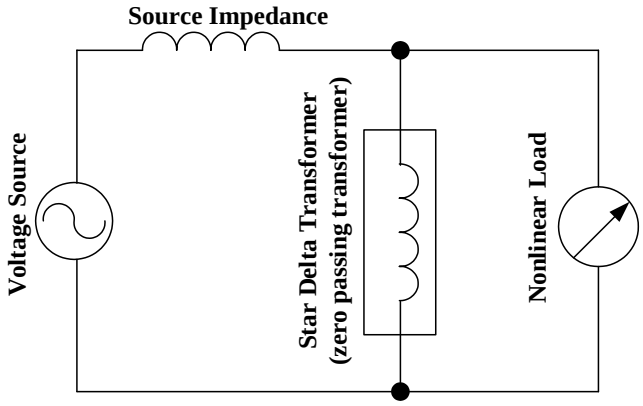

Fig. 2 The equivalent circuits for star delta transformer as a zero passing transformer

The neutral current flowing through the source after the zero passing transformers can be evaluated by using equation (1).

$$I_{NS} = \frac{Z_{OP}}{Z_{OP} + Z_{OS}} I_N \quad \ldots(1)$$

Where,

I_{NS} = Source neutral current after compensation

I_N = Source neutral current before compensation

Z_{OP} = Zero sequence impedance for source

Z_{OS} = Zero sequence impedance for zero passing transformers

From the investigation shows that not all the current harmonics can be reduced by zero passing transformer. Therefore, in order to overcome this problem an additional passive filter (LC) is connected parallel with zero passing transformers.

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C. Integration circuit between zero passing transformer and LC filter

The integration circuit between zero passing transformer and LC filter is proposed so that further harmonic currents cancellation is improved. The main block circuit diagram is shown in Fig. 3.

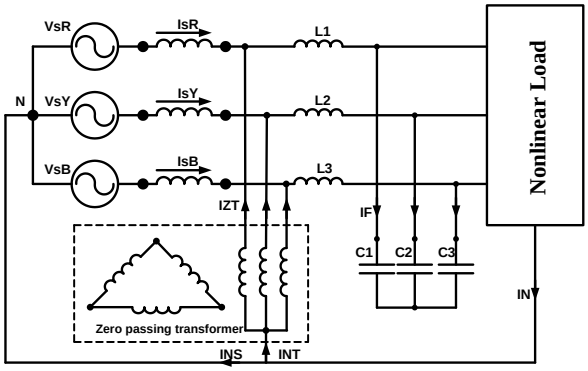


Fig. 3 The integration circuit between zero passing transformer and LC filter

The LC filter is used to tune the 3rd current harmonic because it is the dominant currents harmonic. Once 3rd harmonic is suppressed, the rest of the harmonics will be reduced substantially. It means that the LC filter can assist the harmonic current reduction rather than the star delta transformer alone to cancel the harmonic currents. The LC filter can be designed based on desired harmonic order reduction by using equation (2).

$$f_r = \frac{1}{2\,\pi\sqrt{L\,C}} \quad \ldots(2)$$

Where,

f_r = Frequency resonance
L = Value for inductance
C = Value for capacitance

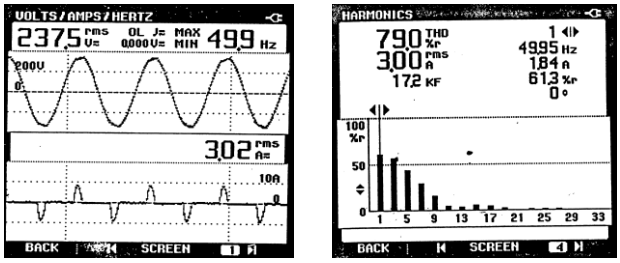
3.0 RESULTS AND DISCUSSION

Table 1 shows the measured phase results for three phase four wire distribution systems. This table shows on the various results between before and after reduction by using different techniques for comparisons purposes.

TABLE 1

Description	Before reduction	After reduce by using stand-alone star delta transformer	After reduce by using stand-alone star delta transformer integrate with LC filter
RMS phase current (A)	3.00	2.75	0.71
RMS neutral current (A)	5.00	4.42	0. 19
THDi phase current (%)	79.0	76.8	6.8
Pf	0.59	0.60	0.76

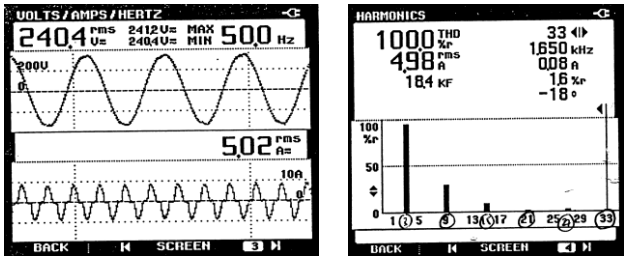
The measured line and neutral current waveforms and their harmonics before reduction are shown in Fig. 4 and 5 respectively.



(a) (b)

Fig. 4 Waveforms and harmonic currents before filter at line (a) Phase current waveforms (b) Harmonic currents spectrum

Fig. 4 shows that the line current before reduction is 3Amp., Total Harmonic Current Distortion (THDi) is 79% and power factor(Pf) 0.59.



(a) (b)

Fig. 5 Waveforms and harmonic currents before filter at Neutral line (a) Neutral current waveforms (b) Neutral harmonic currents spectrum

Fig. 5 shows that the magnitude of neutral current is higher 70% compared with phase current even though the system is balanced condition. In theoretically it should be zero Ampere. However, the neutral wire shows that the THDi is 100%. It means that the neutral wire was polluted with harmonics currents were dominated with 3rd harmonic current.

In order to solve this problem, the star delta transformer acting as a zero passing transformer is installed to the systems. The results of reduction for line current, neutral current and THDi are 10%, 12% and 3% respectively as shown in Fig. 6.

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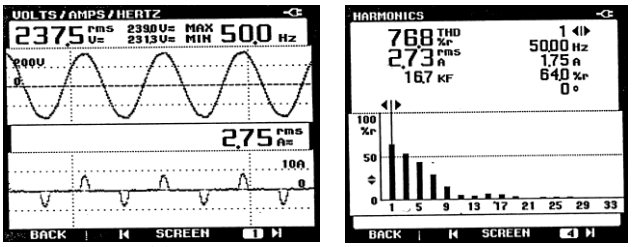
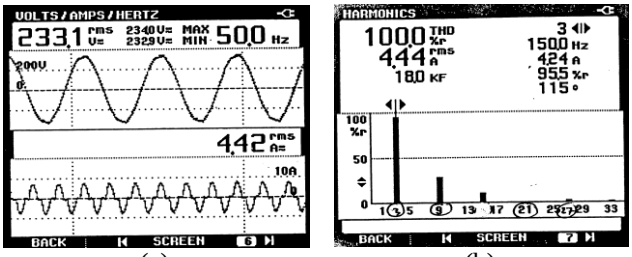


(a) (b)

Fig. 6 Waveforms and harmonic currents after filtered by star delta transformer at line (a) Phase current waveforms (b) Harmonic currents spectrum

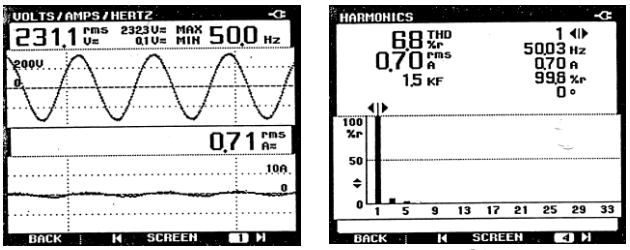
Meanwhile, the neutral current reduction is further reduced 11.6% by using this technique as illustrated in Fig. 7. However, the results obtained are still generated high THDi 100% at neutral conductor.



(a) (b)

Fig.7 Waveforms and harmonic currents after filtered by star delta transformer at Neutral line (a) Neutral current waveforms (b) Neutral Harmonic currents spectrum

Fig. 8 shows that the results for three phase four wire systems was completed developed as proposed.



(a) (b)

Fig. 8 Waveforms and harmonic currents after filtered by star delta transformer and LC filter at line (a) Line current waveforms (b) Line harmonic currents spectrum

Effects from this approached the result shows that the harmonic currents in the line is reduced, THDi line current was reduced 91.3%, Pf improved 28.8% as well as neutral current is 0.19Ampere which is nearly to zero Ampere towards theoretically.

4.0 CONCLUSIONS

The integration between star delta transformers with LC filter to minimize harmonic currents in three phase four wire system is carried out. The experimental results showed that this technique is very significant in reducing the neutral current and harmonic currents in neutral wire as well as to improve power factor in line for three phase four wire distribution systems.

REFERENCES

[1] Ali Mihring, " Harmonic Study Analysis Guidelines for Industrial Power Systems, " 2004 [Online]. Available: http//www.amse.net/c99am.htm.

[2] ABB, " Power Factor Correction with Harmonic Filters, " 2005 [Online]. Available: http//www.abb.com/Global/Abbzh.

[3] Pekik, Dahono A, Radpandji E.W., Syafrudin and Qamaruzzuman, " A Practical Approach to Minimize the Zero Sequence Current Harmonics in Power Distribution Systems, " *IEEE Trans. On PCC-Nagaoka*, 1997, pp.78–86.

[4] CBEMA, " *CBEMA Information Letter ", CBEMA, ESC-3 Committee, CBEMA 311 First Street, N.W.Suite 500, Washington DC.*

[5] Enjenti P.N. , " Analysis and Design of a New Active Power Filter to Cancel Neutral Current Harmonics in Three Phase Four Wire Electric Distribution Systems," *IEEE Trans. On Industry Applications* ,vol. **30**, no.**6**, Nov/Dec. 1994, pp. 34– 42.

[6] Tolbert L.M., Hollis H.D. and Hale Jr P.S., " Survey of Harmonics Measurements in Electrical Distribution System," *IEEE IAS Annual Meeting San Diego, CA.*, 1996, pp. 2333–2339.

[7] IEEE Recommended Practices and Requirements for Harmonic Control in Power System, *IEEE Standard 519- 1992*, pp.107–120.