PERFORMANCE EVALUATION OF HARMONICS ON POWER QUALITY: CASE STUDY

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ABSTRACT: This work is proposed the results of current and voltage measurements in the real low voltage distribution system and explains the effects of Harmonics in the Power System with high accuracy with many factors, the relationship between the load and no load and its effects on electrical equipment are practically analyzed , caused by connecting the resistive load and no loading with conclusion two form frequencies, the system behavior is analyzed using the power quality analyzer device (Fluke-435B). This paper will imitate to these sets and include graphs which should explain the variances between individual power quality disturbances. the analysis of the results with respect to k factor and THD and how these can be analyzed to check more successfully w.r.t IEEE 519 are showed. The elements of the distribution system consist of:1 kVA transformer, load resister, and Adjustable Speed Drivers(ASJ) are modeled.

Keywords: Power System, Harmonics, THDi , THDv, Kfactor, Power quality, LVDS, RERC.

INTRODUCTION

The Harmonic disturbances were principally less in the earlier period as the designs of power systems were very easy and conformist. However, these days with using of compound devices in the industry and traditional harmonic disturbances has too enlarged. So the Harmonics are one of the highest worries in a power system investigates.

There are numerous resolves aimed at the standards which are taking from the power quality. One of the highest details is the consumers are well informed about the power quality subjects like interruptions, sagging and switching transients. Besides, many power organizations are internally joined to low voltage network. The component of electrical power (current and voltage) distortion waveforms caused by harmonics are realizing to weaken of the power systems analyses [1,2]. The harmonics produce in a power system from two different forms of loads. The First type of loads is entitled the linear loads. The linear time-invariant loads are deliberated which the function of sinusoidal voltage outcomes in a sinusoidal drift of current. Aconstant steady-impedances are directed from these loads through the applied sinusoidal signals. The Non-linear loads are considered the second kind of loads. The application of sinusoidal voltage does not consequence in a sinusoidal flow smeared sinusoidal voltage for a non-linear devices.
The non-linear loads draft a current which may be discontinuous and distortion. The power system in the Iraq uses a fundamental frequency of 50 Hz. All loads are reproduction to receive untainted sinusoidal waveforms however due to non-linear loads, the untainted sinusoidal waveforms are distorted by electromagnetic phenomena called harmonics [3,4, 5]. Harmonics are contenting of the signal that frequency is an integer multiple of the system's fundamental frequency, Harmonics for this frequency are shown in Table 1.

Table 1: Fundamental frequency of 50 Hz and its harmonic values

Nth Harmonic	Fundamental	2nd Harmonic	3rd Harmonic
N(50) Hz	50 Hz	100 Hz	150 Hz

The other variables may be ducked as the dc presents a less angle pattern and the detailed analytical procedure is functional [6]-[8]. This detailed analytical procedure (DAPs) uses the Laplace transformation requires estimations of lengthy inverse Laplace transformations [6] or the state variable approach [7]. Once a study is complete, a report will be issued containing:

Voltage & current harmonic distortions
Graphical one-line display of harmonic results
Voltage & current harmonic spectrum plots
Updated one-line diagram (optional)
Fundamental load drifts outcomes
Recommendations for corrective action

This paper presents a measurement of the total harmonic distortion levels and k-factor created by ASD in building contents of twenty labs. materials, Refrigeration & Air Conditioning,electrical test, solar energy, electronic lighting ballasts, uninterruptible power supplies,Number of printers therefore, The effect of phase shift transformers and distortion are inspected and cast-off as methods to analyses the harmonic distortions.

POWER LOSSES

The Non-linear loads that cause harmonics are magnetic devices, converters, and rotating machines. Many motors that are used in industrial applications are collected of magnetic materials and are driven by a changing flux and magnetic field. This increasing a back electromotive force (EMF) and straight contributes to a form of harmonic distortion known as as voltage distortion. The harmonic currents are generated by non liner loads, additional losses in the transformers feeding the loads. The overall load loss be able to be listed as:[9]-[11].

$$R_{EC_R} = R_{AC_R} - R_{DC} \quad (1)$$

$$R_{EC_R} = R_{AC_R} - R_{DC} \quad (2)$$

$$P_{Load} = I2\ R_{DC} + P_{EC} + P_{OSL} \quad (3)$$

$$P_{Load} = I2\ R_{DC} + P_{EC} = I2_{RDC} + I2\ R_{EC} - R(f_h/f_L)2 \quad (4)$$

Table 2: Fundamental frequency of 50 Hz and its harmonic values

PLoad	The totalload of the transformer
I	the rms current
R_{DC}	Winding DC resistance
P_{DC}	the winding eddy-current loss
$R_{EC\text{-}R}$	is the equivalent resistance corresponding to the eddy-current loss
f_t	The Individual harmonic
f_L	The Fundamental frequency
POSL	POSL is the other stray loss

Small dc modules (up to the rms magnitude of the transformer excitation current at rated voltage) are predictable to have no effect on the load carrying capability of a transformer determined by this optional practice. Higher DC components may unfavorably affect transformer proficiency and should be avoided [12]-[14]. In observation, it is important to use the real harmonic current values sooner than theoretical values [15].

ESTIMATION OF HARMONIC LOAD METHODS

The IEEE Standard 1100-1999 distinct power quality disturbances based on the wave shape. There are five primary categories of waveform distortion:

1. DC offset
2. Harmonics

3. Inter harmonics
4. Notching
5. Noise

There are three methods for estimation harmonic load content:

Total Harmonic Distortion(THD)

Distortion Index, the best commonly used directory for computing the harmonic gratified of a waveform, is the total harmonic distortion (THD). It is a degree of the actual importance of a waveform and can be practical to both voltage or current. Just as waveforms can be added to generate imprecise signles, distorted components may be decomposed into fundamental and harmonic signles. This guide can be intended for either current and voltage. [8,9,16]. The following formulas are computing the total harmonic distortion for both 17

$$\%THDI = \frac{\sqrt{\sum_{h=2}^{h=\infty}(Ih)^2}}{I1} \qquad (5)$$

$$THDi = \sqrt{(\frac{\text{Irms}}{\text{I1}})^2 - 1} \qquad (6)$$

$$\%THDv = \frac{\sqrt{\sum_{h=2}^{h=\infty}(Vh)^2}}{V1} \qquad (7)$$

$$THDv = \sqrt{(\frac{\text{Vrms}}{\text{V1}})^2 - 1} \qquad (8)$$

K-Factor Rated Transformers

K-factor transformers are considered to stream non-sinusoidal loads, and there are used smaller, insulated, the secondary conductor in matching to reduce skin effect, but that is more expensive than conventional transformers[8,9,16].The zero sequence current goes in the neutral as the majority harmonic current frequencies comprise harmonic components consuming multiples of (3,6.9…etc.).

$$K = Pt/Pf = \sum_{h=1}^{h=\infty}(Ih)^2\, h^2 \qquad (9)$$

Crest factor method

It is means of determining the max load that can be safely placed on a transformer which deliveries harmonic loads.By definition, a perfect sine wavecurrent or voltage will have a crest factor of 1.414, and any deviation fromthis value represents a distorted waveform[11,12,13].

$$CF = \frac{\textit{Peak Magnitude of current waveform}}{\textit{True RMS of the current}} \qquad (10)$$

HARMONIC LIMITS (DISTORTION LIMITS)

Bear in mind that ahead of harmonics may still be necessary, whether or not the aim is to meet IEEE Std. 519-1992 standards. In low-voltage schemes (600 V or less), capacitors are generally the deepest impedance at harmonic frequencies, and practice as a result high RMS currents and enlarged the temperature that sources them to burn.

Harmonics Stander Limit

According to IEEE 519, harmonic voltage distortion on power systems 69 kV and below are restricted to 5.0% total harmonic distortion (THD) with each harmonic restricted to 3%. The harmonic current limits vary based on the shortcircuit strength of the system they are being injected into basically, the new system can hold harmonic currents, The utility switches providing a clean voltage to the customer.

ISC/IL Ratio

As presented in Table 2 and stated previously in this work, the harmonic limits which apply to a particular customer depend on the ISC/IL ratio at that customer's point of common joining with the utility. As distincted in IEEE 519 ISC is the maximum short-circuit current at PCC. This should be a three-phase bolted fault current. This is a current calculated from the maximum billing (e.g. 15 or 30minute) demand, not an instantaneous peak—avery important distinction. This ratio indications the relative impact that a given customer can have the utility. Acustomer with a small demand relative to the short circuit current available cannot cause much disruption to the utility system. The actual measurement on non-linear devisees is very imported to devices specifications in zones and construction such that the maximum total harmonics distortions (THD) of circuit currents,at rated load conditions, shall be restricted to those figures as presented in Table 3 below.

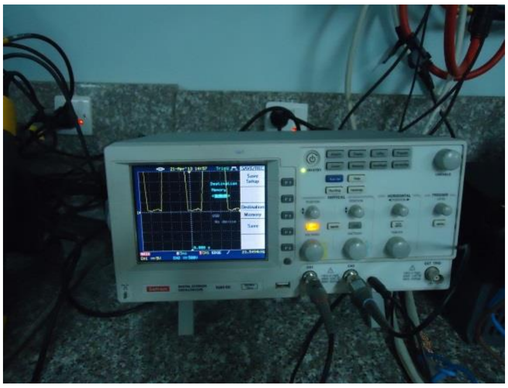
Table 3. Maximum THD of current in percentage of fundamental

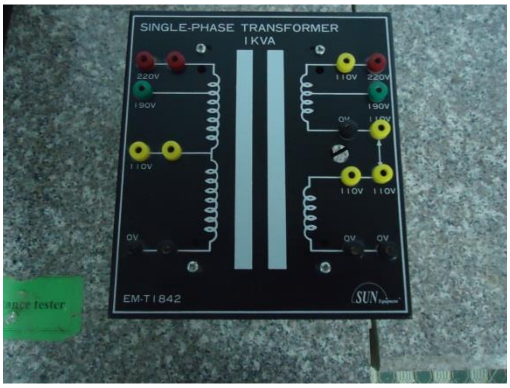
Circuit Current at Rated Load Condition 'I' at 380V/220V	Maximum Total Harmonic Distortion (THD) of Current
I<40A	20.0%
40A≤I<400A	15.0%
400A≤I<800A	12.0%
800A≤I<2000A	8.0%
I≥2000A	5.0%

The maximum acceptable of fifth harmonic current distortion (THDi5) at the Adjustable Speed Drives (ASD) operation within the variable speed range is less than 35%. The compensation group at sub-panel is accepted in this state [18].

EXPERIMENTAL SETUP

The experiments parts were performed on a single phase transformer. The results value is very accurate because All result parameters were got with theFluke-435B power quality analyzer. Open- Circuit and Short-Circuit tests were applied to a 1kVA, 220/105-V single-phase transformer.





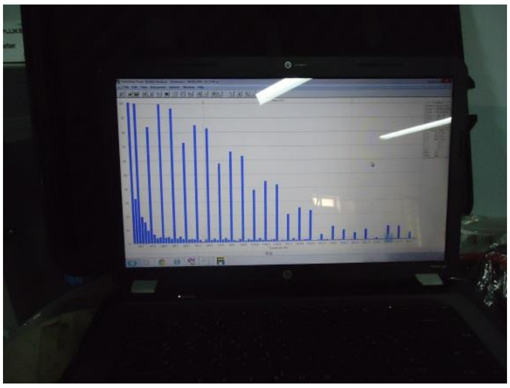


Table 4. List of used components in the experiment

item	Model number(specifications)
ASD	N700E
Power quality analyzer	Fluke-435B
Many Variable resistors	From 500w to 1000w
435BStorage oscilloscope	SFRAM
Transformer	1KVA
Personal Computer	

Figure 1. Practical experimental components Harmonics Effect at Frequencies.

RESULTS and DISCUSSION

Using mat lab Program, the values of internal resistance is showed for different frequencies, according to noload and load at Fig(2) and Fig(3), without DC effects, the normalize of the first one is 0. 1263 and the second one is 0. 1466 for 16 points used for fitting for each other at 50 Hz.

The Total Harmonic Distortion (THD) Using power quality analyzer, is computed at the PCC and (fig.6 to fig.11) show that. Results are presented in approximate percentage of the 50 Hz component. The current flow in the neutral is distorted with following percentage, At no load case the THDi and k factor 57.4%,14.6 respectively. However, at load THD and k factor 64.9%,19.4 respectively. The increasing value of Thai and k factor is 11.55%,24.74 respectively.

The current flow in the line is distorted with following percentage, At no load case the Thai and k factor 77.6%,81.3 respectively. Though, at load THD and k factor 230.1%, 178.3 respectively. The increasing value of Thai and k factor is 66.27%,54.4 respectively.

The voltage distortion in the neutral is distorted with following percentage, At no load case the THDv =67.9%. But at load THDv = 88.6 %,. The increasing value of THDv is23.36%, the Total Harmonic Distortion (THD) is computed at the PCC For 50 Hz show that.

At 400 Hz, (fig.12 to fig.17)The current flow in the neutral is disfigured with following percentage. At no load case the THDi and k factor 68 %, 21 respectively. However, at load THD and k factor 108.6%, 36.3 respectively. The increasing value of THDi and k factor is 37.3% 42.2 respectively.

The current flow in the line is distorted with following percentage. At no load case the THDi and k factor 226.6% 169.8 respectively. However, at load THD and k factor 182%, 93 respectively. The increasing value of THDi and k factor is (- 24.5 %,-82.5) respectively. The voltage distortion in the neutral is distorted with following percentage. At no load case the THDv = 90.8%. But at load THDv = 38.3 % The increasing value of THDv is (- 1.37 %).

Table 5. Parameters Analysis under states of variable Load Conditions

		April(A)	Armsl(A)	Arms 9N(A)	ApkN(A)	Vrms (V)	Vpk (V)	THDil	K factor	CFLv
At 50hZ no load	Resistive load	11	2	2	4	227.52	317.5	77.6	81.3	1.40
At 50 hz load		11	2	2	4	225.69	316.2	230.1	178.3	1.4
At 400hz no load		6	1	1	2	229	326	226.6	169.8	1.41
At 400 hz with load		13	4	1	4	220	310	182	93.7	1.42

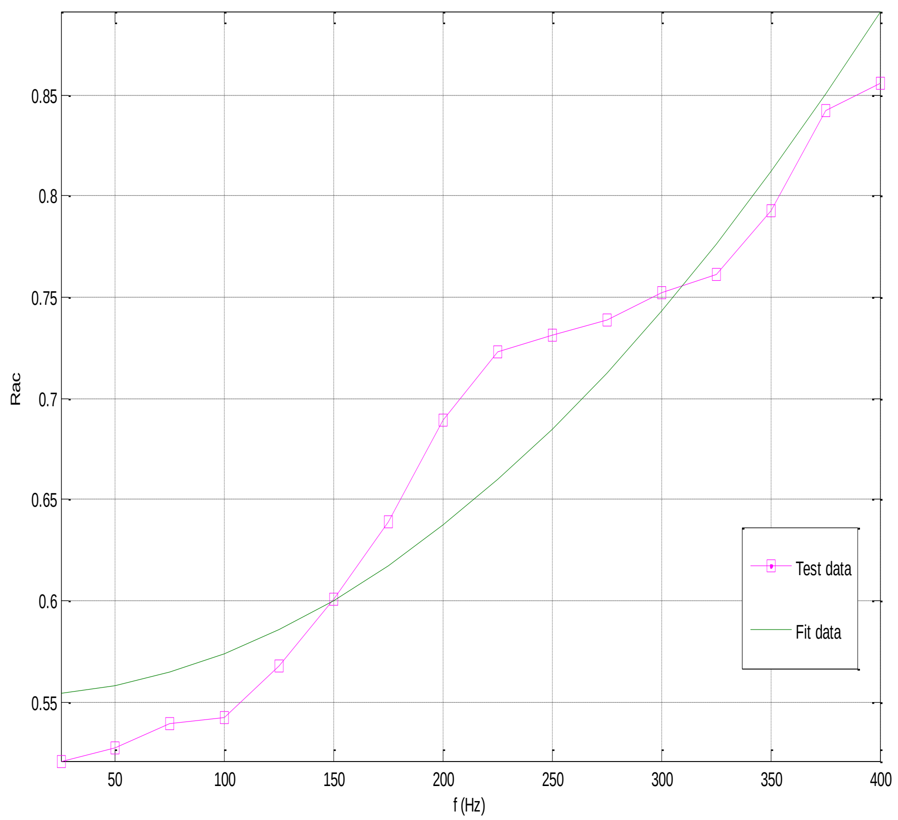


Figure 2. At no load

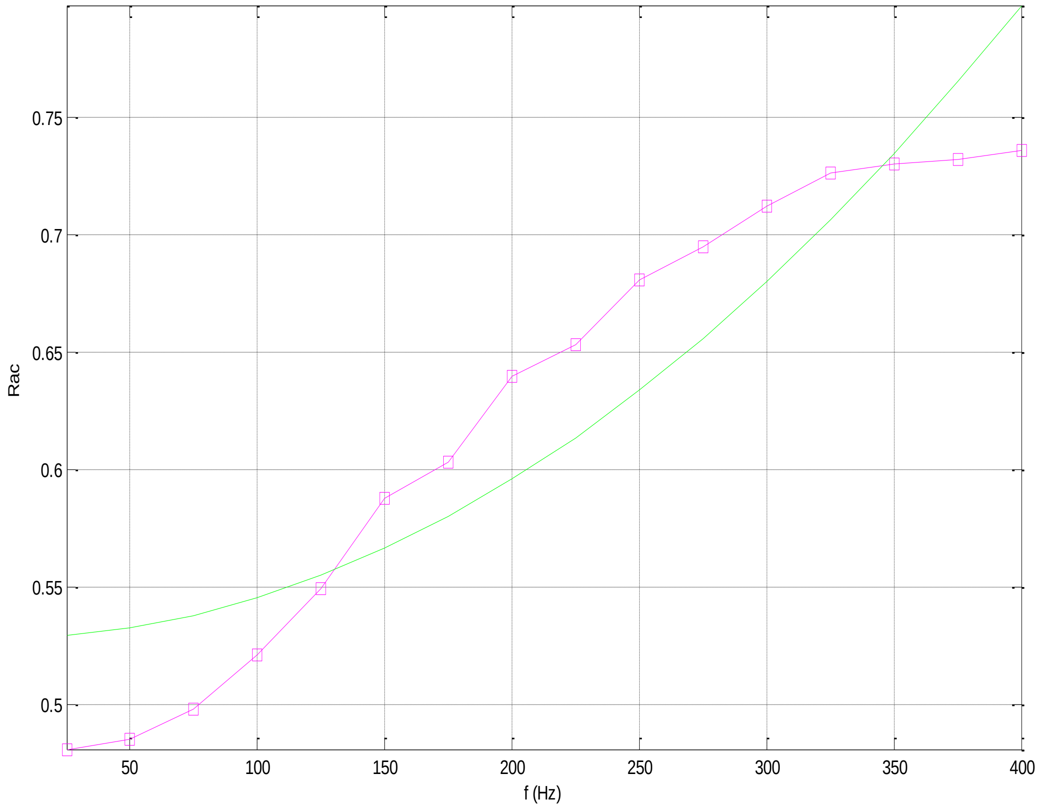


Figure 3. At load

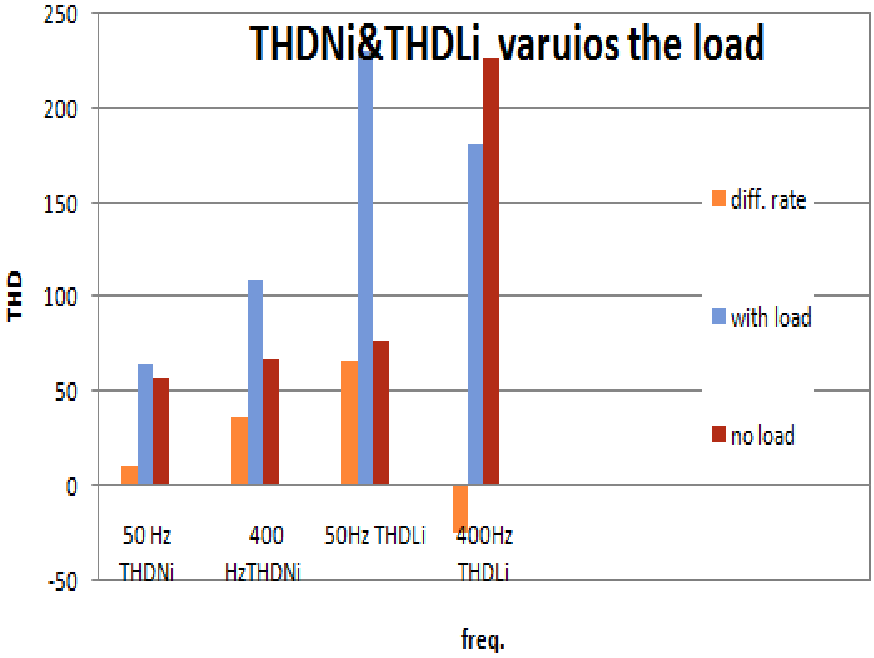


Figure 4. Amplitude of THDNi and THDLi at (50Hz and 400Hz) with and without resistive load (neutral and line for the current waveform)

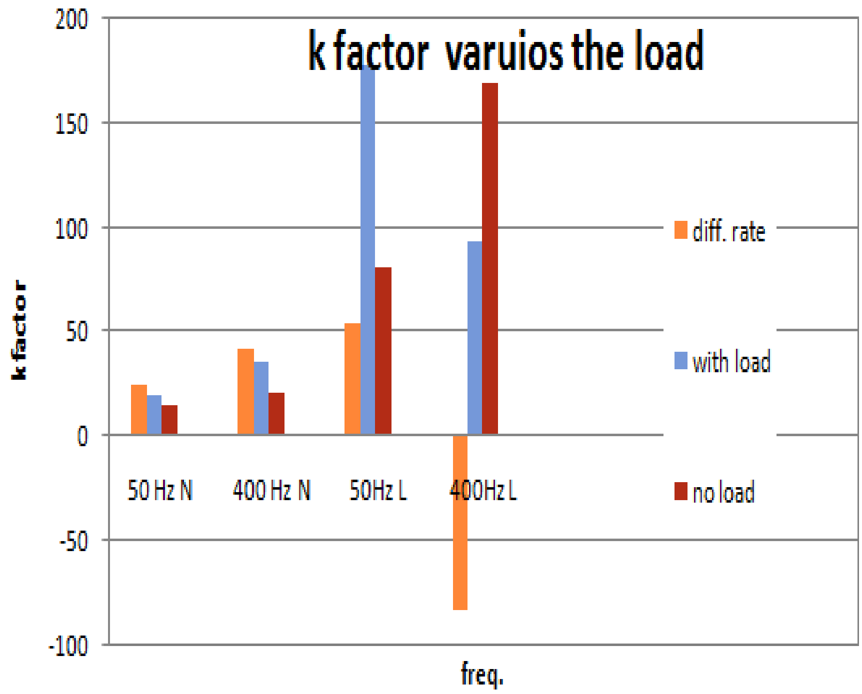


Figure 5. Amplitude of the k factor at (50Hz and 400Hz) with and without resistive load (neutral and line for the current waveform)

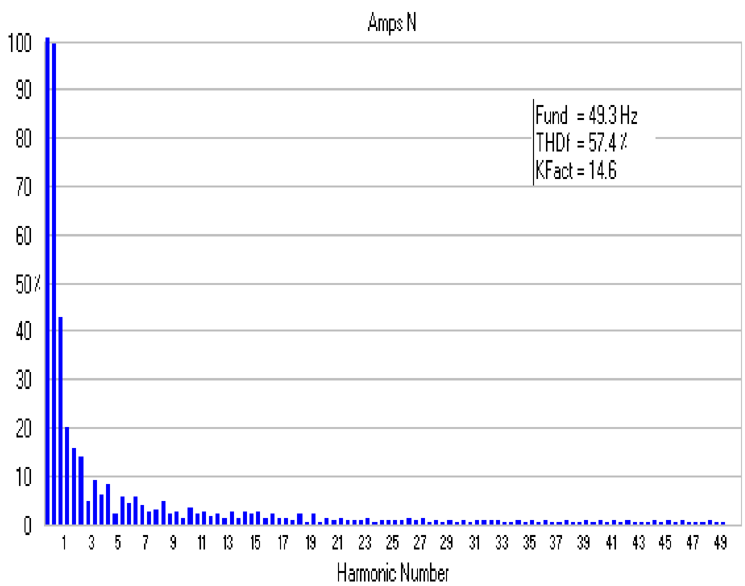


Figure 6. Amplitude of Harmonics at 50Hz without resistive load (neutral line for the current waveform)

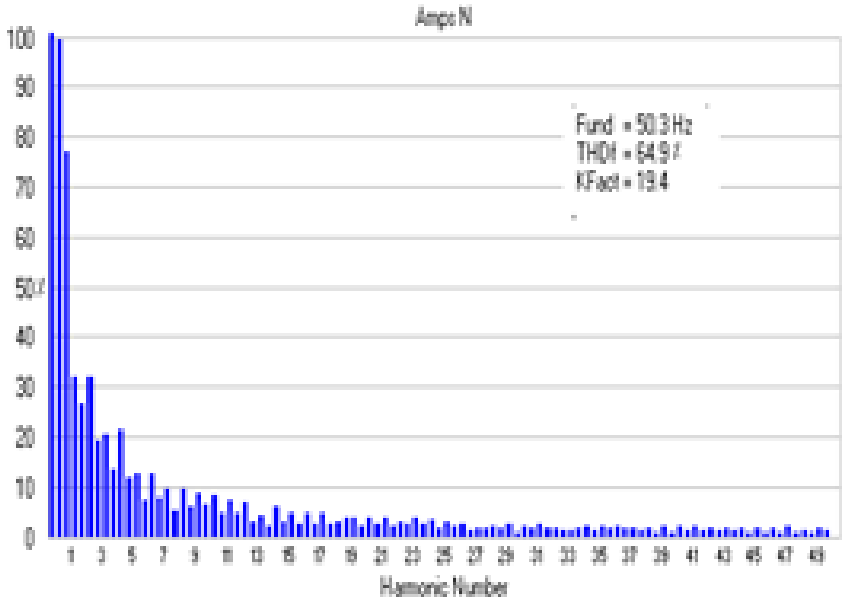


Figure 7. Amplitude of Harmonics at 50Hz with resistive load (neutral line for the current waveform)

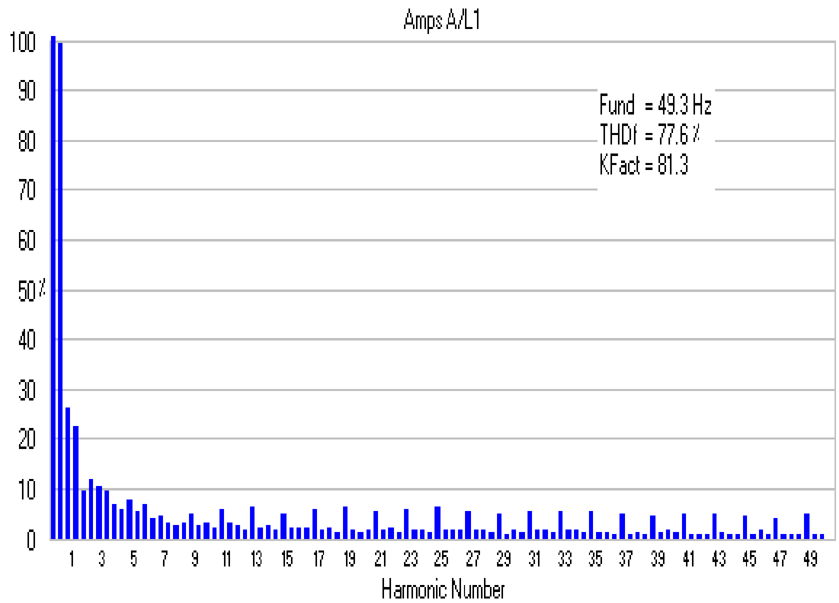


Figure 8. Amplitude of Harmonics at 50Hz without resistive load ((Line harmonics for the current waveform)

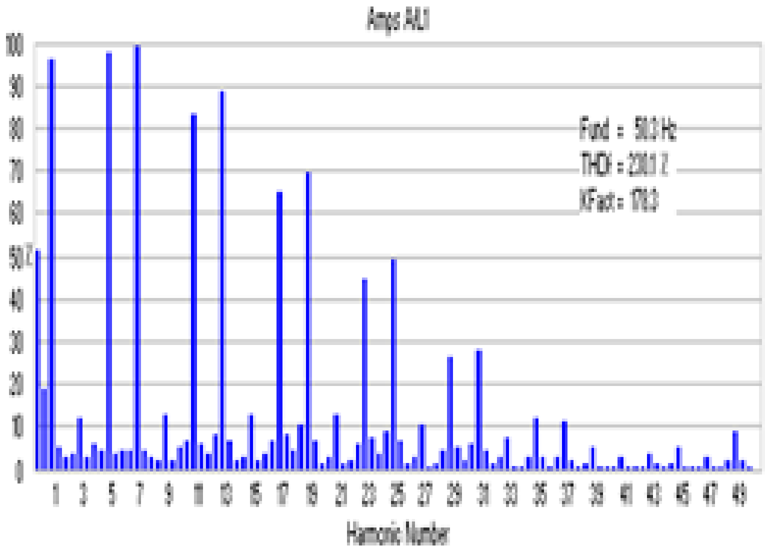


Figure 9. Amplitude of Harmonics at 50Hz with resistive load ((Line harmonics for the current waveform)

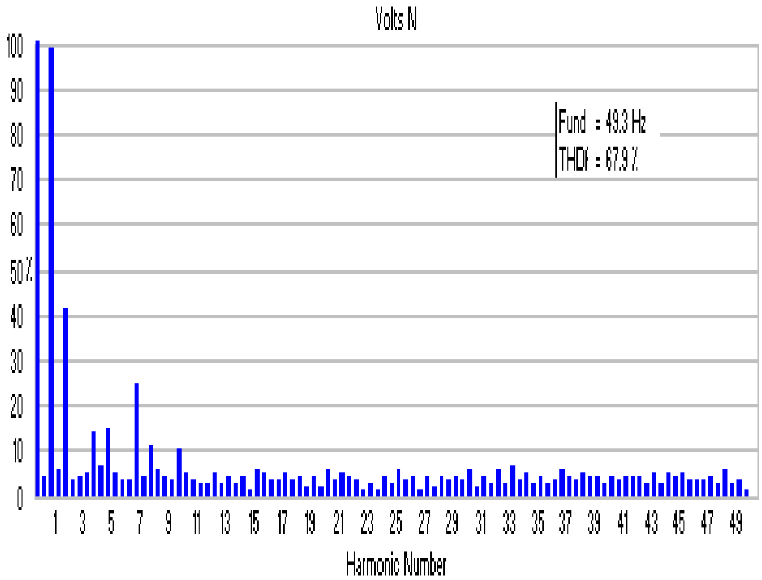


Figure 10. Amplitude of Harmonics at 50Hz without resistive load (Neutral Line harmonics, volt)

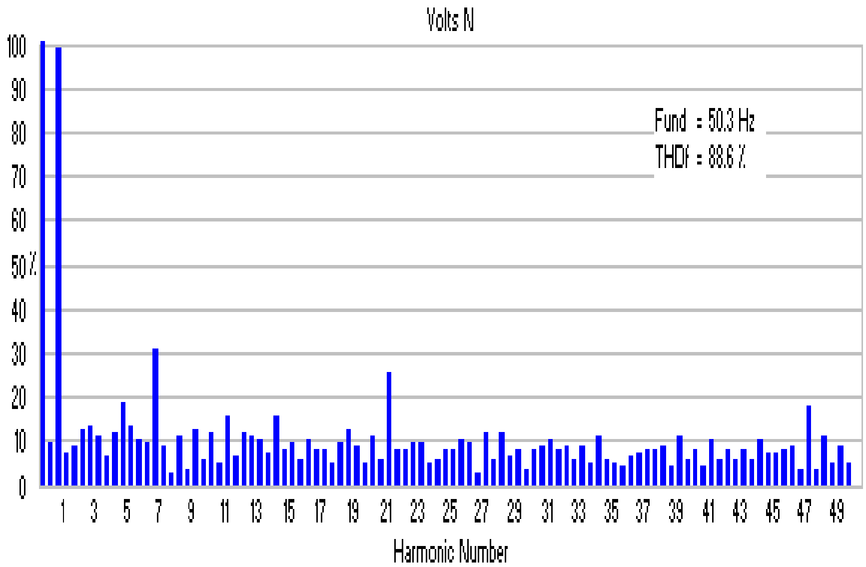


Figure 11. Amplitude of Harmonics at 50Hz with resistive load (Neutral Line harmonics, volt)

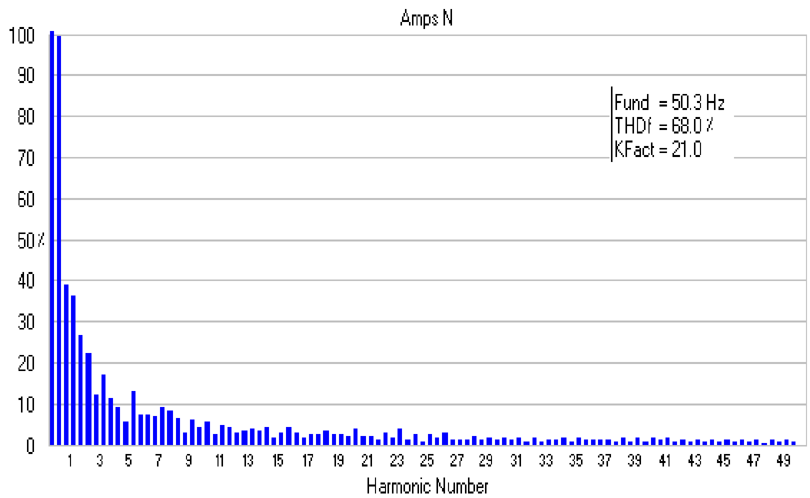


Figure 12. Amplitude of Harmonics at 400Hz without resistive load (neutral line for the current waveform)

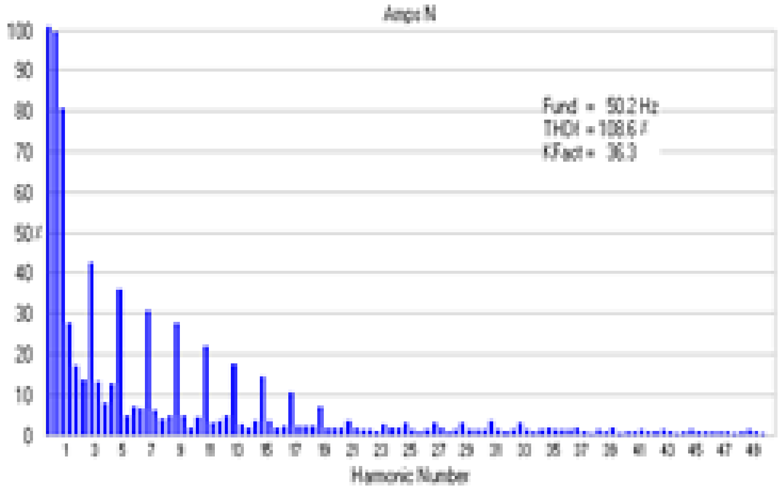


Figure 13. Amplitude of Harmonics at 400Hz with resistive load (neutral line for the current waveform)

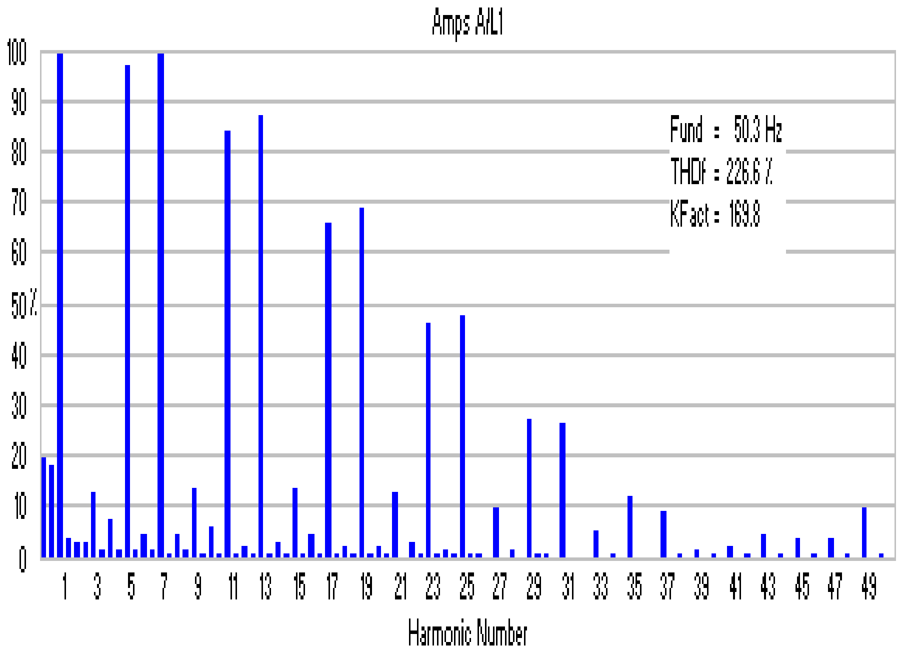


Figure 14. Amplitude of Harmonics at 400Hz without resistive load (Line harmonics for the current waveform)

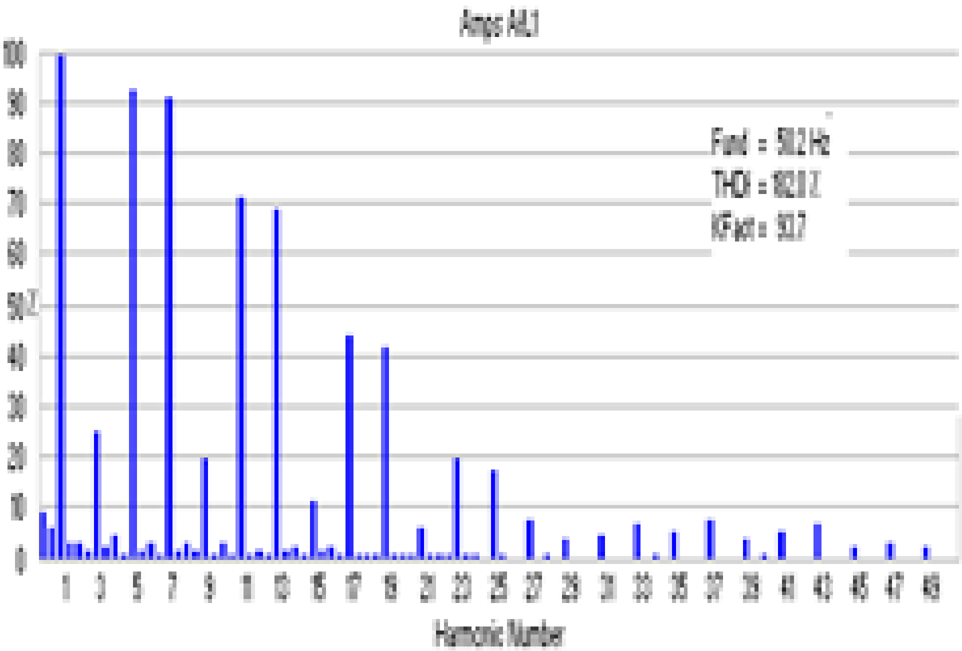


Figure 15. Amplitude of Harmonics at 400Hz with resistive load (Line harmonics for the current waveform)

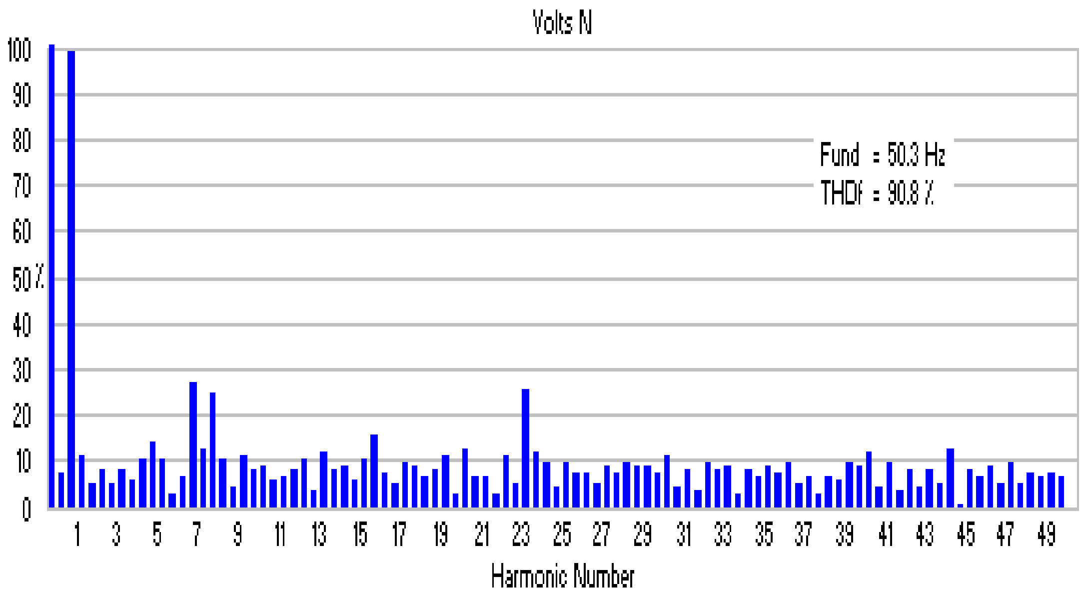


Figure 16. Amplitude of Harmonics at 400Hz without resistive load (Neutral Line harmonics, volt)

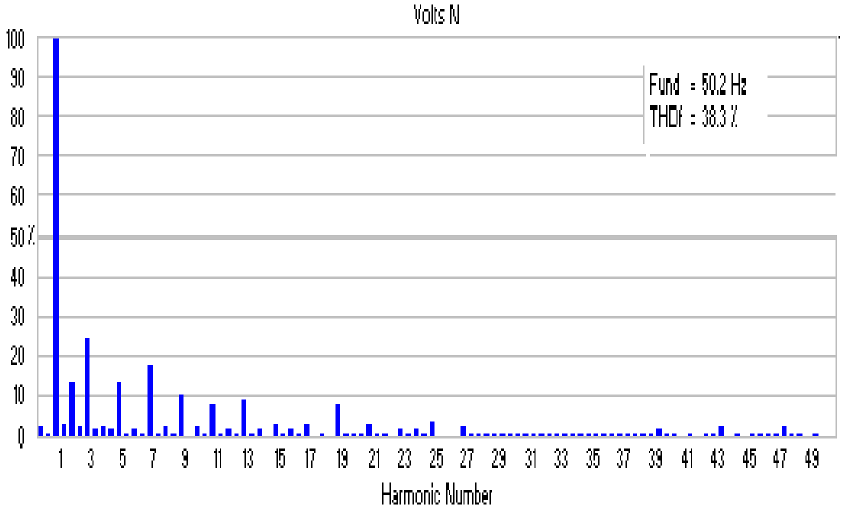


Figure 17. Amplitude of Harmonics at 400Hz with resistive load
(Neutral Line harmonics, volt)

CONCLUSIONS

In this investigation two kinds of frequency, the first50 Hz and the second 400Hz under no load and pure resistive load. At no load and load Have been observed of THDNi increasing with frequency,the values w.r.t the line distortion it low because overlap waveform,the phase shift between the phases decreases, PCC and flow direction of all harmonics. The behavior at no load and load of THDLi is changed at 400 Hz only where the value of THDLi at no load higher than load because changed the electrical load of building. The behavior of the THD is the same behavior of K-factor However, this values exceed over the rate of IEEE 519(I<40A) cause by their many technical labs, in this building of RERC. Both No load and Load losses are effected by the presence of harmonics in load currents. However, the variation in load losses contributes more to excessive heat generation in distribution transformer. The Fluctuation between the high and the low-frequency especially at increasing the load is present this must take into consideration when designing and manufacture of Electric devices.

RECOMMENDATIONS FOR FUTURE WORK

New laboratory tests on dissimilar transformers are required. A wide study of loads such as the individually of the inductance or capacitance is required for finally this issue. To rise above this state the optional action is to twice over the size of the neutral.

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