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Investigate the Effect of Different Combination of Loads on Harmonic Distortion

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Abstract— The scope of this paper is to investigate the harmonic distortion at the output of a power control system due to different combinations of reactive loads. In this paper to investigate the effect of loads (RLC) on harmonic distortion in the input and output voltage of the system is calculated. Different combinations of the load are taken inductance ranging from 1.232H to 269.1mH keeping resistance 36Ω and capacitance 50μF is constant. Input and output voltages waveforms were recorded processed using Gold wave and digital signal processing software respectively. The sampling rate and duration of measurement are kept at value of 16000 and 1second respectively. A computer algorithm is designed to calculate total harmonic distortion (THD), in the input and output of the system.

Keywords— Harmonic, loads, power system, THD

I. INTRODUCTION

Electric power is an important and indispensable energy in modern society. However, a large number of non-linear power and electronic devices that occurred in modern power systems with the technology development results in high-order harmonic in power-net getting worse. It directly distorts current and voltage waveform periodically, among which a series of component sine waves (high harmonics) with frequency multiples of the fundamental frequency. The high harmonics is called power harmonics [1], [2] Power system harmonics have become one of the important indexes rating power quality issues. Good power quality means less distortion and fewer harmonic in the voltage and current sources. There are many different approaches to the measurement of harmonics, such as the Fast Fourier Transform (FFT), application of adaptive filters and neural networks [3], [4], [5]. .Most of the home appliances including Television, Hi-Fi systems, Compact Fluorescent Lamps, Personal Computers (PC) and different devices chargers use the rectification phenomena producing harmonic distortion [6], [7], [8].A term generally deployed to compute the harmonic pollution The total harmonic distortion (THD) is defined as the ratio of the RMS value of the waveform excluding the fundamental components, to the RMS fundamental magnitude. When no DC component is present, this can be mathematically written as [9], [10].

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_{gn}^2}}{I_{g_1}} \quad (1)$$

In this research work is carried to investigate the effect of different loads i.e. varying the values of inductance keeping resistance and capacitor is constant. Signal processing technique is used to evaluate the effect of the impedance and calculation of THD.

II. METHODOLOGY

Figure 1 exhibits the schematics block diagram of the system by taking the 230 V, 50 Hz AC from the main supply. It consisted of four blocks such as power system, combination of RLC load, load voltage level shifting, sound card with PC and signal processing unit. First block is a power system and contains voltage measurement circuits, microcontroller based stabilization and input voltage level shifting. Input voltage is applied to the first bock which is working as power system and then output stabilized voltage received from the power system after all removal of fluctuations of elevation and dropping voltage by the stabilizer, microcontroller and drivers circuits. The microcontroller used in the power system is dsPIC30F2010. All decisions regarding stabilization of the power are taken by the microcontroller. The

microcontroller is connected to the stabilization which contains IGBT(CT60), current mode PWM contrioller ,TLP250, gate driving circuit of IGBT and other peripheral devices.

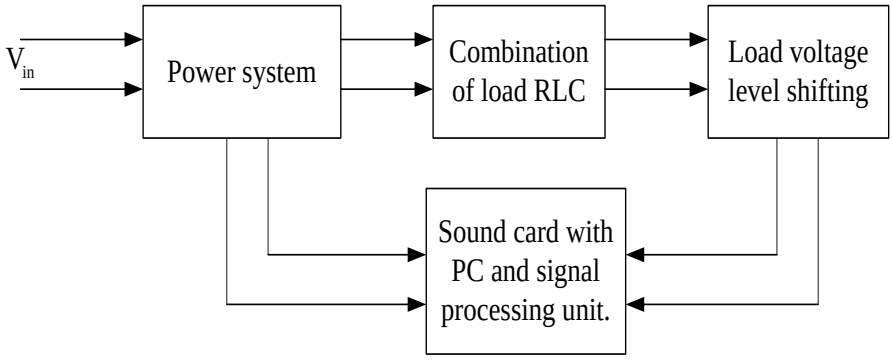


Figure 1: Block diagram of the system

The output from power system is applied to load which consists of series combinations of resistor, inductor and capacitor. Different combinations of impedance are taken as shown in Table I. Now the experiment is done by taking eight combination of load and keeping value of inductance ranging from 250mH to1200mH and keeping resistance 36Ω and capacitor 50μF .The input and output voltages are recorded in the PC using sound card and voltage level shifting block. This block is required to bring down the voltage level from hundreds of Volts to millivolts. So that it can be applied to sound card. Signals are recorded and processed using Goldwave and digital signal processing software respectively. The sampling rate and duration of measurement are kept at value of 16000 sa/s and 1 s respectively.

TABLE I
DIFFERENT COMBINATIONS OF LOAD RLC

S. No.	R (Ω)	L (mH)	C(μF)
1	36	1232.0	50
2	36	1073.0	50
3	36	873.0	50
4	36	729.0	50
5	36	590.6	50
6	36	470.2	50
7	36	363.0	50
8	36	269.1	50

THD of the input and output signals are calculated using signal processing technique. The flow diagram of the designed computer algorithm to calculate the THD is shown in Figure 2.

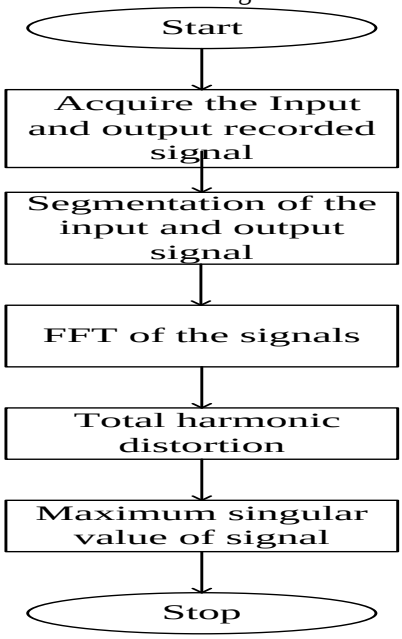
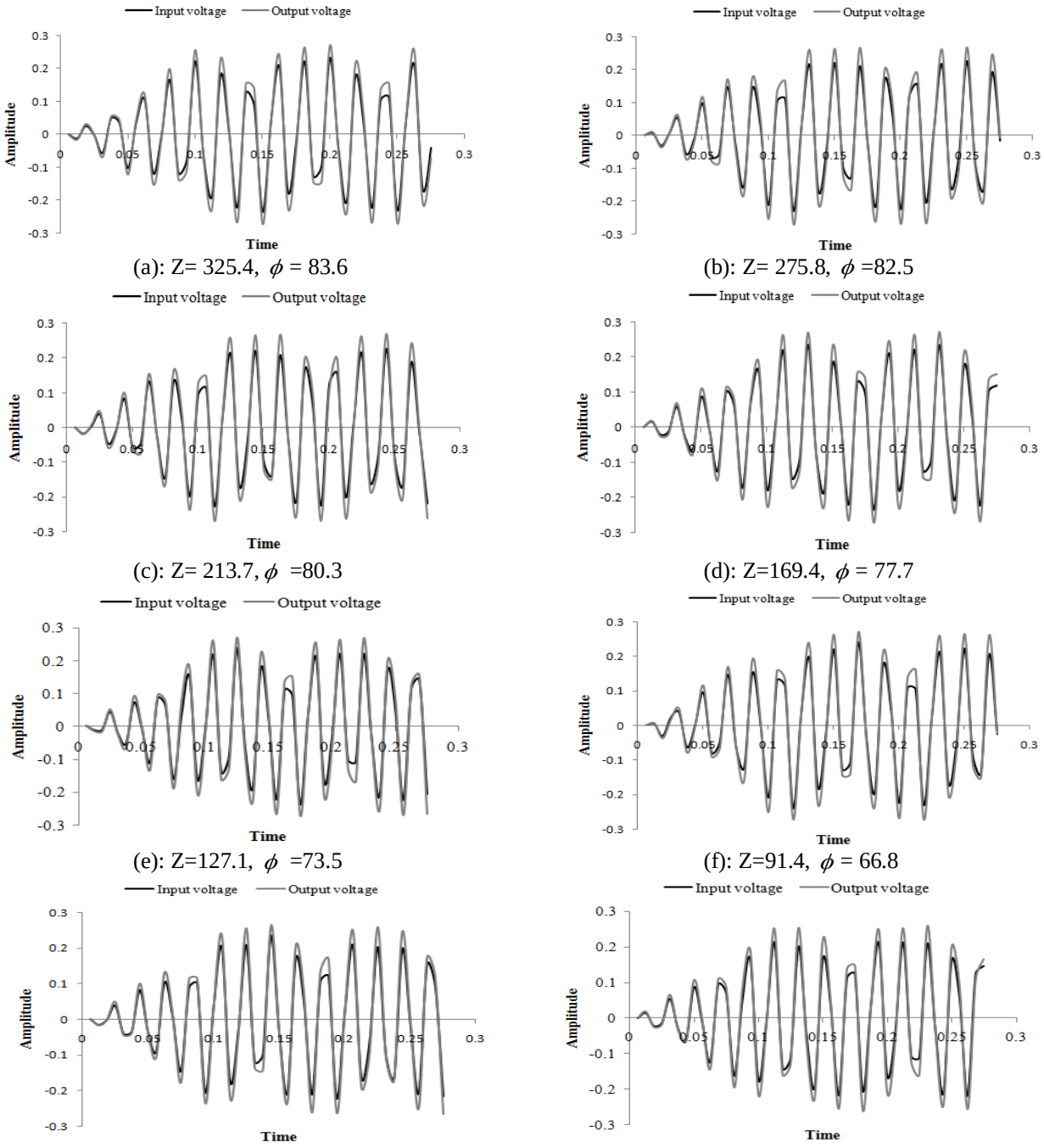


Figure 2: Algorithm flow chart to calculate input and output signal of THD

III. RESULT AND DISCUSSION

The experiment is carried out to analysis the harmonic distortion in the input and output voltages caused by different combinations of inductive, resistive and capacitive load. Load Combinations of RLC are taken in the experiment. Input and output waveforms of voltages for various combinations were recorded for limited time duration of 1 second with sampling rate of 16,000. Segment of the signals are taken and harmonic distortion in them are calculated. Figure 3(a) to Figure 3(h) represents the segmented of input and output voltage waveforms for eight different combinations of the load with duration of 0.26 second. The calculated value of impedance, input and output THD for eight different load values are given in Table II.



(a): Z= 325.4, ϕ = 83.6 (b): Z= 275.8, ϕ =82.5

(c): Z= 213.7, ϕ =80.3 (d): Z=169.4, ϕ = 77.7

(e): Z=127.1, ϕ =73.5 (f): Z=91.4, ϕ = 66.8

(g): Z= 61.9, ϕ = 54.5 (h): Z= 41.6, ϕ = 30.1

Figure 3(a-h): Input and output voltage signals with eight varying values of inductance and constant values of resistance and capacitance for duration 0.26second

The calculated experimentally values of input and output of THD are plotted with different values of impedance as in Figure 4. As the values of the impedance is decreased from Henry (H) to mH, the input and output value of THD rises giving maximum and minimum values of 0.2886 and 0.1425 and output value is 0.2093 and 0.1035 respectively. There may be some difference in input and output value of THD seen in the plot for certain combinations which are due to leakage of the inductive or capacitive components. Form the calculated values of THD in input and output it is observed that the harmonic distortion in the output is comparatively less than the input.

TABLE II
INPUT AND OUTPUT VALUE OF THD FOR LOAD RL WITH CAPACITOR 50µf

S. No.	Impedance (Z)	Input THD	Output THD
1.	325.4	0.2130	0.1599
2.	275.8	0.2584	0.1960
3.	213.7	0.2004	0.1503
4.	169.4	0.1425	0.1035
5.	127.1	0.2855	0.2093
6.	91.4	0.2210	0.1625
7.	61.9	0.2886	0.2071
8.	41.6	0.1747	0.1338

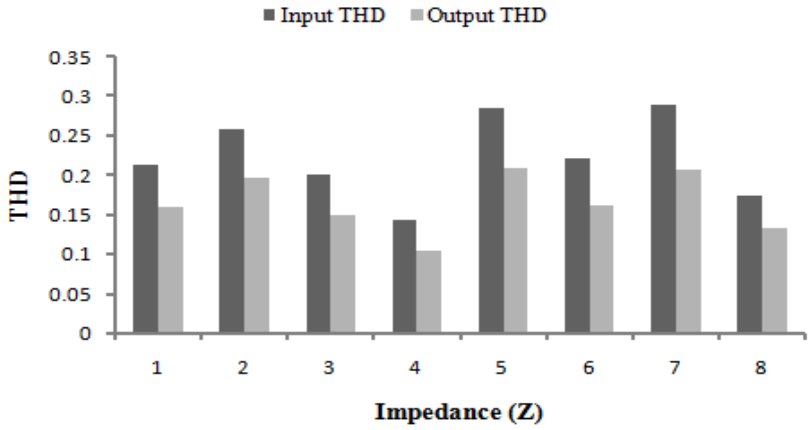


Figure 4: Calculated value of input and output THD with different of impedance value

IV. CONCLUSION

In this research work investigations were carried out to study the effect of reactive loads on harmonic distortion at the output of automatic power control system. Different combinations of the load were taken with varying values of inductance keeping resistance and capacitance as constant. Input and output voltages were recorded for all combinations using at a sampling rate of 16,000 sa/s and duration of 1 s. Computer algorithm was developed to evaluate THD in the input and output voltages of the system with the help of digital signal processing techniques. It was observed that maximum value of THD in the input was 0.2886 and the corresponding value for the output THD was 0.2093. Hence, the designed power system is able to reduce the harmonic distortion.

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