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Investigation of Harmonic Distortion for Frequently Changing Input Voltage

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***Abstract*—**This paper present the concept of improving harmonic distortion in power systems. Investigations were carried out for studying the effect of range dependent voltage switching and random voltage switching (sudden changes) in the input line voltage on the harmonic distortion at the output of the system. The analysis of the results showed that the insulated gate bipolar transistor (IGBT) based power system using the concept of switching resistor is capable of reducing harmonic distortion on the input power lines introduced because of external or internal load conditions. Harmonic distortions in the input and output of the conventional systems are estimated and compared. Reduction in the total harmonic distortion (THD) was also investigated for the proposed IGBT based power system.

***Keywords*—**Harmonic; IGBT; total harmonic distortion; dsPICmicrocontroller; signal processing technique; power system.

I. INTRODUCTION

In the last couple of decades harmonics have become a major power quality problem in electric power systems. It is important to identify the harmonic sources in the system to solve and prevent harmonic related problems [1], [2]. Power systems with low harmonic distortion are the key requirement in the modern electronic power systems. Mostly, the power systems are based on switching of the transformer tapings for changing the output voltage. The switching of tapings also introduces distortion in the output. In this paper novel approach using a switching resistor is proposed for reducing the distortion. Investigations are carried out to analyze the effect of load on the IGBT based power system developed using the concept of switching resistor. The scope of this research paper is to evaluate the harmonic distortion in modern power systems under different load conditions [3-15].It has been observed from the literature review that more sophisticated systems are designed using IGBTs and dsPIC controllers. These systems may introduces or improve the amount of harmonic distortion in the output due to fast switching. The objective is to study the harmonic distortions of such systems as a result of varying the loads connected at the output.

The research work is carried out to investigate the effect of varying voltage due to range dependent voltage switching and random voltage switching keeping inductance, capacitance and resistance are constant on the designed power system. Signal processing technique is used to calculation of THD.

II. METHODOLOGY

The figure 1 shows the block diagram of the system. It consist of six blocks namely variac, multimeter, power system, series combination of RLC load, load voltage level shifting, sound card with PC and signal processing unit. Input supply is given to variac ranging from 0 to 250 volt which is connected to the system for variation of voltage and also connected to the multi-meter for observing the input voltage. The output from the variac is applied to power system circuit. Power system block contains voltage measurement circuits; microcontroller based stabilization and input voltage level shifting. The voltage measurement circuit which consists of current transformer stabilizes the voltage.

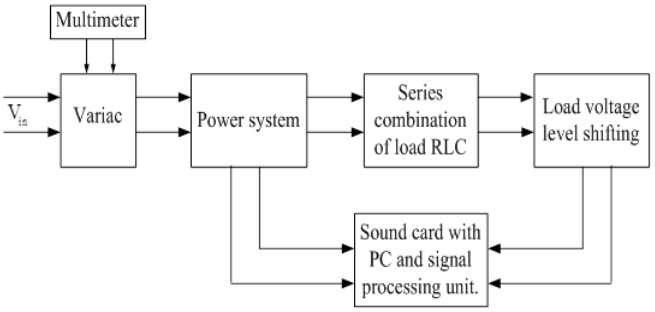

Fig. 1. Block diagram of the experiment.

The microcontroller based stabilizer whose, main function to elevate or drop in the input voltage caused by the fluctuations are stabilized which also consists of microcontroller and driver circuits. The controller used in this circuit is DSPIC controller dsPIC30F2010. All decisions regarding stabilization of the power are taken by the microcontroller. The controller is connected to the stabilization block which contains IGBT (CT60), TL3842P current mode PWM controller, TLP250 gate driving circuit of IGBT and other peripheral devices through an isolator circuit consisting of HEF4050B buffer HEX non inverting buffer isolators and IRFBE30 MOSFET. The output from power system block is applied to load. Load consists of series combination of power resistor, capacitor and inductor. These three combinations are used in the experiment. The input and

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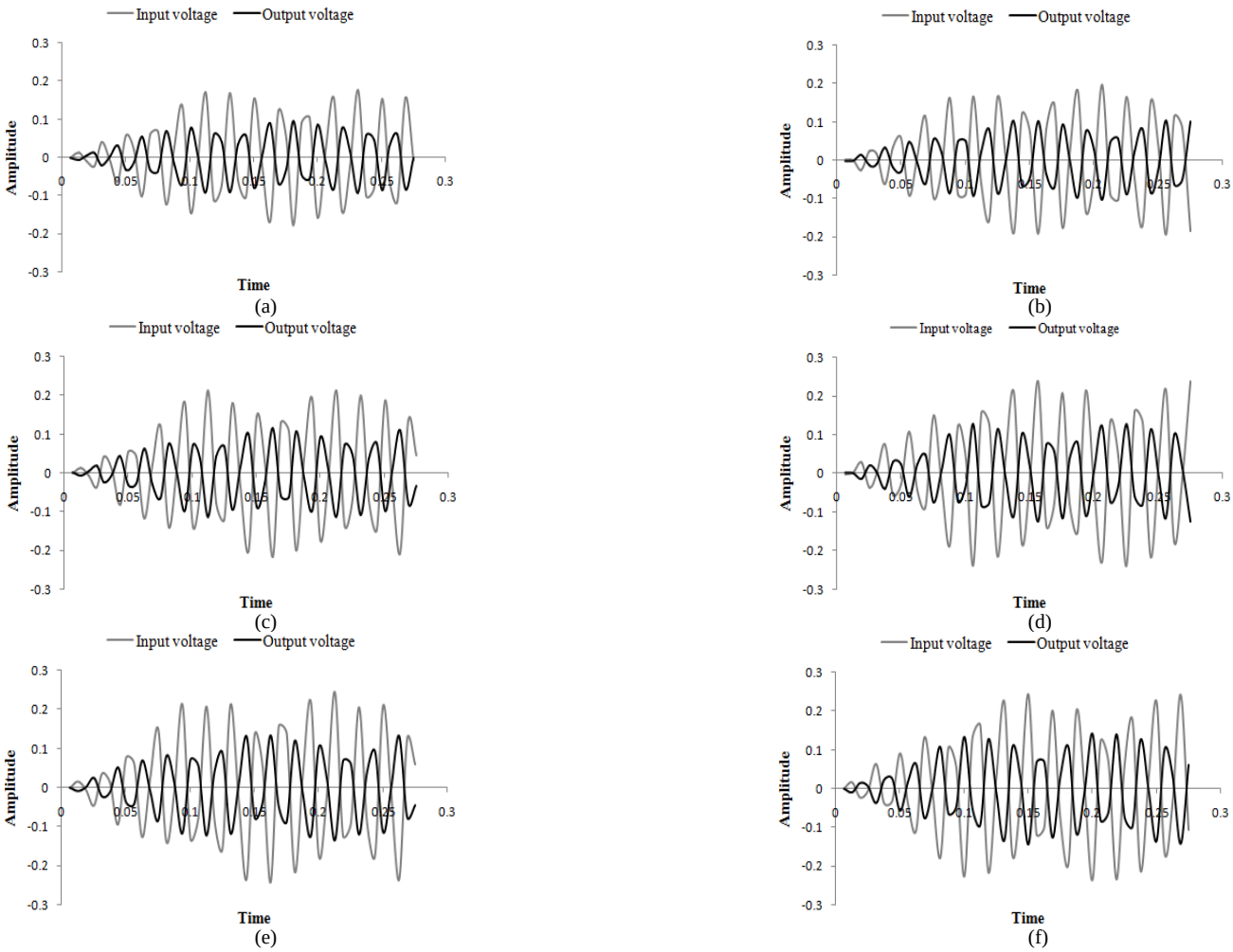
output voltages are recorded in the PC using sound card and voltage level shifting block. Thus it cannot be directly applied to the sound card, as circuit is developed to bring down the voltage level from hundreds of volts to millivolts. Signals are recorded and processed using Gold wave and digital signal processing software respectively.Input and output signals of total harmonic distortion are calculated by using the signal processing technique. Note the observation by changing the variac into two parts as under; in the first part of the experiment to investigates the change in harmonic distortion due to range dependent voltage switching. We take the reading of input and output voltage after every 10V intervals by changing the variac that's ranging is 100 to 250 volts and also take the reading of variable voltage of load with AC input and output. The second part of the experiment to investigates the change in harmonic distortion due to random voltage switching. By suddenly changing the variac the effects are observed on the harmonic distortions and keeping all the conditions same as discussed in first part.

III. Results And Discussion

To analysis harmonic distortion in the input and output caused by the variation of voltage and keeping the resistance, capacitor and inductance are constant. Input and output values of THD due to varying voltage are noted after duration of every 10V with the help of variac for limited time duration of 1s and sampling rate of 16,000sa/s as shown in table I. The segments of signals are taken and processed to evaluate theharmonic distortion. Figure 2(a-p) represents the segmented input and output voltage waveforms for varying voltage and combinations of the load with duration of 0.3s.The calculated values of input and output of THD are plotted due to variation of voltage as shown in figure 3. As the value of voltage is increased then the input value of THD rises giving maximum and minimum values of 0.3126 and 0.1428 and output value is0.2207 and 0.1018 respectively. Difference of input and output value of THD which can be seen in the plot is due to leakage of inductive and capacitive components. From this it is observed that that harmonic distortion in the output is less than the input and output values of AC with loads are shown in table II.

When switched on the system it gives the values of AC input and load. Thus the output of the system is connected to variable rheostat and also connected the multimeter and the output of variable rheostat gives the value of AC output due to variation of voltage we take 10V gap for variation of voltage. Input and output AC voltage due to varying voltage are plotted due to variation of voltage as shown in figure 4.



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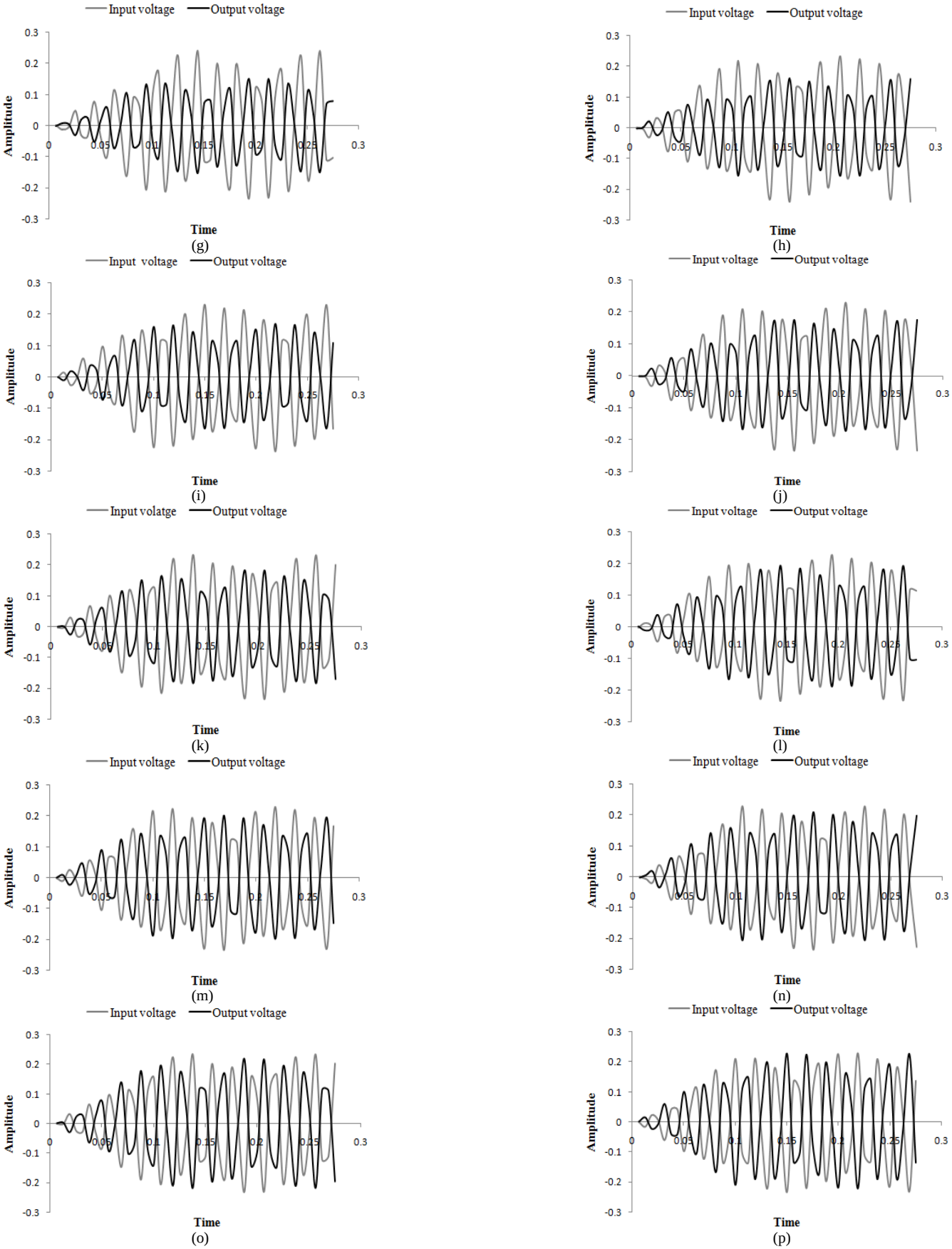

Fig. 2(a-p). Represents the segmented input and output voltage waveforms for varying voltage.

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Table I. Input and output value of THD for range dependent voltage switching.

S. No.	Varying Voltage (volt)	Input THD	Output THD
1	100	0.1873	0.1308
2	110	0.2731	0.2067
3	120	0.1490	0.1130
4	130	0.2460	0.1704
5	140	0.1717	0.1084
6	150	0.2802	0.1925
7	160	0.1497	0.1365
8.	170	0.2659	0.1897
9	180	0.2890	0.2211
10	190	0.2210	0.1635
11	200	0.2713	0.1978
12	210	0.1428	0.1018
13	220	0.3080	0.2111
14	230	0.1670	0.1432
15	240	0.2619	0.1977
16	250	0.3126	0.2207

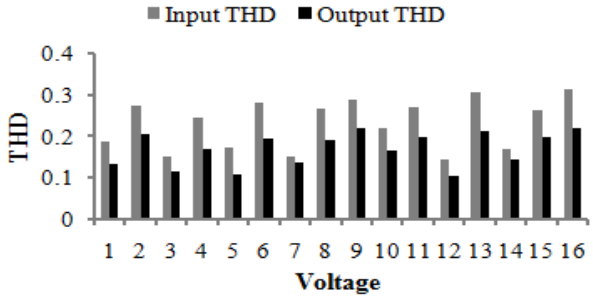

Fig. 3. Experimentally value of input and output THD due to variation of voltage.

Table II. Input and output value of AC voltage with load.

S. No.	Varying Voltage(volt)	AC Input(volt)	AC Output(volt)	Load (volt)
1	100	99	167	105
2	110	108	183	143
3	120	188	198	169
4	130	128	214	210
5	140	139	219	221
6	150	148	219	183
7	160	159	219	188
8	170	168	220	198
9	180	178	220	182
10	190	188	218	178
11	200	198	219	206
12	210	209	218	211
13	220	218	219	223
14	230	228	220	238
15	240	240	220	242
16	250	250	220	255

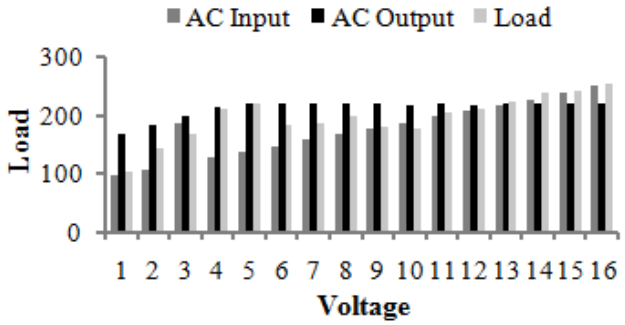

Fig. 4. Input and output AC voltage with load due to varying voltage.

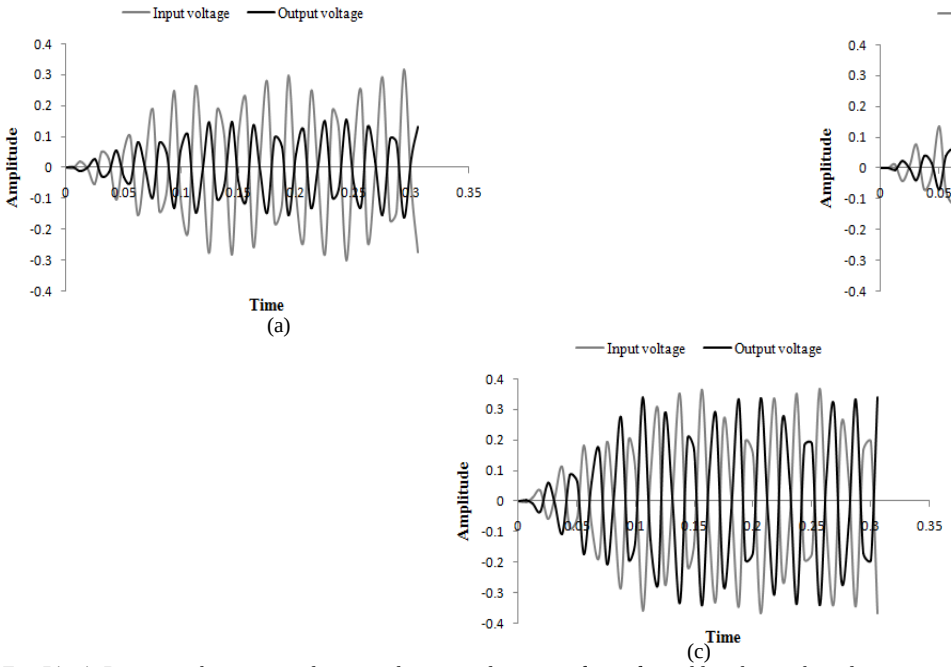

Fig. 5(a-c). Represent the segmented input and output voltage waveforms for sudden change the voltage.

Analysis the harmonic distortion in the input and output value of THD obtained by the random change (sudden change) of voltage from the variac with the same load combinations of resistance, capacitance and inductance as in first part for time duration of 1s and sampling rate 16000 sa/s. Segment of the signals are taken and harmonic distortion in them are

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calculated. Figure 5(a-c) represents the segmented input and output voltage waveforms for sudden change the voltage and combinations of the load with duration of 0.3 s. The calculated value of input and output THD for random voltage switching are shown in table III.

Table III. Input and output value of THD for random voltage switching.

S. No.	Random voltage (V)	Input THD	Output THD
1	96 to 228	3.0792	2.4137
2	113 to 226	5.0394	3.2214
3	243 to 134	2.9577	2.1897

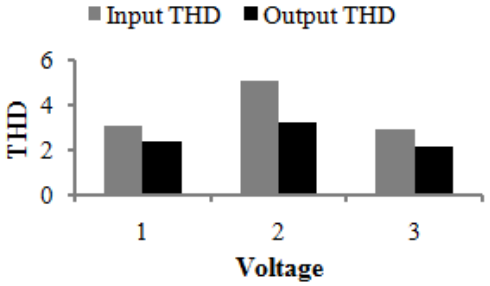

Fig. 6. Experimentally value of input and output THD with the sudden change of variac rheostat.

The calculated experimentally values of input and output of THD are plotted in figure 6 with sudden change of voltage than the input and output value of THD rises giving maximum and minimum values of 5.0394 and 3.0792 and output value is 2.9577 and 2.1897 respectively. Some difference in input and output value of THD can be seen in the plot for certain combinations which arises due to leakage of the inductive or capacitive components and observed that the harmonic distortion in the output is comparatively less than the input.

IV. CONCLUSION

Investigations were carried out to study the effect of switching resistor connected at the output of an IGBT based power system on harmonic distortion in the output. The change in the harmonics distortion due to range dependent voltage switching and random voltage switching was investigated and also investigated the effect of stabilized/unstabilized voltage on the harmonic distortion. It was observed that the harmonic distortion in the output voltage was comparatively less than the input voltage.

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