

Harmonic Analysis of Output Voltage of Single phase AC Voltage Controllers

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Abstract— The harmonic analysis of output voltage of single phase AC voltage controller was well known. But, it has been found that less harmonic analysis and comparison between voltage dimmer and thyristorised AC voltage controller. This paper presents such an analysis on the AC voltage controller using TRIAC, thyristor and voltage dimmer circuit. Results are obtained from simulations as well as hardware implementation and results were compared.

Keywords- TRIAC, THD, AC Voltage controller, Thyristor,

I. INTRODUCTION

A TRIAC or thyristor switch is connected between source of AC and load, the flow of current can be varied by varying the rms value of ac voltage applied to the load [1]. Some of the main applications of AC voltage controllers are for domestic and industrial heating, transformer tap changing, light control, speed control of single phase and starting of induction motor [2].

The AC power can be regulated by two methods: first one is on-off control and second one is phase control [1]. In the method of phase control, switches connected the load to the AC source for a portion of each cycle of input voltage. The main unpalatable point in AC voltage controller is the introduction of harmonics in power quantities waveform at reduced output voltage levels.

While the analysis of output voltage harmonics of AC voltage controller has been widely explained in various power electronic books. These textbooks have a rather detailed study of the harmonics at the output of AC controller, but a comparison of simulation and laboratory implementation is lacking, especially from the practical concern. The main watchword of this paper is to study the harmonic analysis of AC voltage controller circuit using simulation as well as experimental methods.

The study starts with the harmonic distortion at the output voltage of AC voltage controller circuit. OrCAD 16.6_ lite_all_product spice simulation is used to verify the total harmonic distortion. For more comparison of the THD level of output voltage, a laboratory setup is being used to obtain actual hardware measurements.

II. COMPUTER SIMULATION

Following, the Fourier series analysis is a computer simulation using OrCAD spice. The schematic used in simulating the AC voltage controller circuit shown in Figure 1. The schematic model of the AC voltage controller circuit was constructed by using diode and S-break and same circuit was reconstructed by using SCRs in hardware measurement.

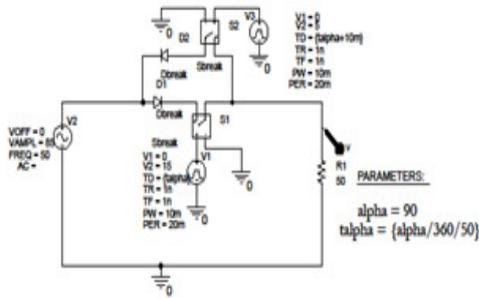


Figure 1. Schematic ACVC

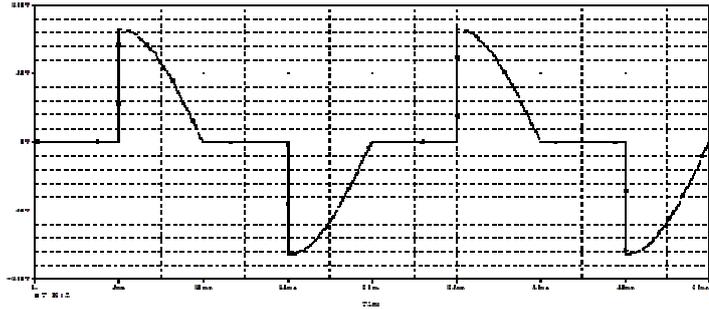


Figure 2. Output Waveform at a 45degree

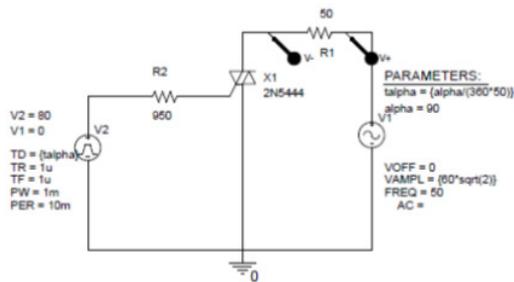


Figure 3. Schematic ACVC by TRIAC

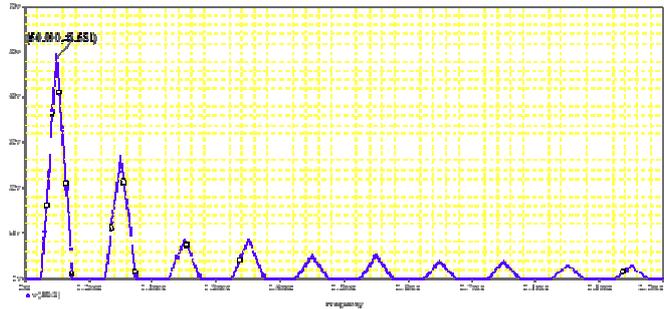


Figure 4. FFT of Output Waveform at a 45degree

Figure 2 illustrates the output voltage waveforms and figure 4 depicts FFT of output voltage of an AC voltage controller when the firing angle is set at 90 degree. As expected waveforms are distorted due to the delay of the conduction of the current into the load. Figure 3 depicted the schematic implementation of TRIAC for simulation.

III. HARDWARE MEASUREMENT

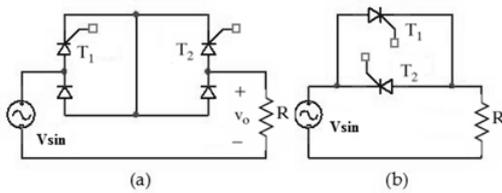


Figure 5. ACVC circuits



Figure 6. Power Kit

The Figure 1 was configured using Thyristor in Pragna make power kit. The AC voltage controller by using TRIAC as well as two - diode and two thyristor models as shown in fig 5 was built on the power kit. The potentiometer was used to vary the firing angle on Pragna make power kit.

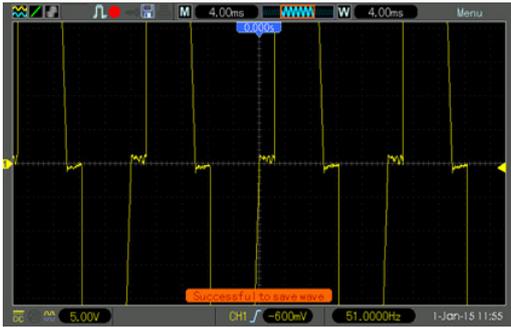


Figure 7. Output Waveform at a 45degree



Figure 8. FFT of Output Waveform at a 45degree

The FFT analysis and data was collected from Aplab (DSO) Digital storage oscilloscope. The figure 7 shows the captured output waveform at 45° from Aplab DSO. It can be seen that this waveform resembles the waveform of figure 2. The harmonic content of the waveform was captured at 45° firing angle it was shown in figure 8.

IV. DISCUSSION

Table1. shows the summary of the results from computer simulation. First, the table shows that, the 0.126 THD difference between Schematic (Ideal) and TRIAC AC voltage controller. Secondly, we can observe that the THD results closely relate from 45° to 90°. Outside of this range there is difference of 2.75% THD between the AC voltage controllers. This is mainly caused by amount of spikes as well as non-sinusoidal waveform that worsens as firing angle exceeds 90 degree.

Table1. Summary of THD in simulation

Firing angle (in degree)	Schematic ACVC	TRIAC
0	0.512	0.386
45	23.71	23.18
90	60.75	59.68
135	119.33	116.48

Table 2. Summary of THD in experimental

Firing angle (in degree)	TRIAC	Two SCR	Two SCR and Diodes
0	0.326	0.328	0.333
45	24.44	21.32	20.77
90	59.75	59.01	53.74
135	143.09	165.64	135.53

Table2. shows the summary of the results from experimental implementation of circuits. Firstly, from the table it shows that the experimental results were close to the simulation results within the range of 90° firing angle. At outside of this range 20-30% THD was found between the AC voltage controllers. But AC voltage controller with diode was good controller even at more than 90° firing angle.

V. CONCLUSION

In this paper THD of AC voltage controller was investigated. The investigation made by implementing the AC voltage controller circuits in simulation and experimental process. The computer simulation followed by using ORCAD 16.5 lite spice. A hardware experiment was conducted on Pragna make power electronics kit and Aplab DSO was used to determine the FFT.

At outset, large harmonic at increased firing angle. This is an important quality to note. The harmonic filters may be necessary to protect the device. This paper effectively demonstrate for the beginner to understand harmonic analysis in AC voltage controller circuit.

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