새로운 교류 전압조정회로 개발

이 종 무, 변 영 복, 김 종 수, 조 기 연
한국 전기 연구소 전력 전자 연구실

A Novel AC Voltage Regulator Topology

Jong-Moo Lee, Young-Bok Byun, Jong-Soo Kim, Ki-Yeon Joe
K.E.R.I. Power Electronics Lab.

Abstract

This paper proposes a novel AC voltage regulator topology. The output voltage is varied by controlling voltage drop of the transformer which is connected with load in series. The waveform of output voltage is clamped sinusoidal, then harmonic components are remarkably decreased compared with conventional phase control method.

The feasibility of proposed topology is verified experimentally.

Introduction

Up to now, there are various topologies about AC voltage regulator.

Conventionally , thyristor phase control method is widely used because of simplicity in main and control circuit. But input power factor is decreased as output voltage is decreased, also radio noise is generated because load current is abruptly rising at switching instant.

AC chopper method using the self-turn-off switching device requires complex control circuit and freewheeling path is needed at inductive load, also stress for the switching device is very strong.

Also high frequency link inverter method is complex and power is converted with 4 stage. Then energy conversion efficiency is low.

Here, this paper proposes a novel AC volage regulator topology. The output voltage of proposed topology is varied by controlling voltage drop of the transformer which is connected with load in series. The waveform of output voltage is clamped-sinusoidal, then harmonic components are remarkably decreased compared with conventional phase control method.

The Principles of Proposed Topology

Fig.1 shows a proposed AC voltage regulator topology. The proposed circuit has a transformer which is connected with load in series. Rectifier and inverter part are located at secondary of the transformer for output voltage control and inverter part converts rectified power to source.

Thyristor inverter part generates reactive power and output voltage is controlled by the reactive power control.

Firing angle of the thyristor is ranged from 90 to 180 degree for inverting operation.

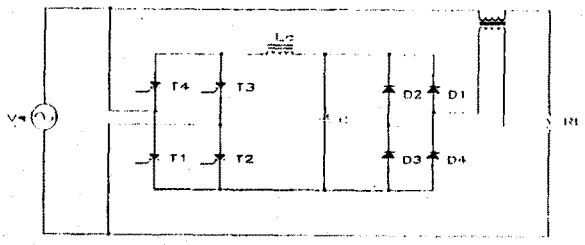
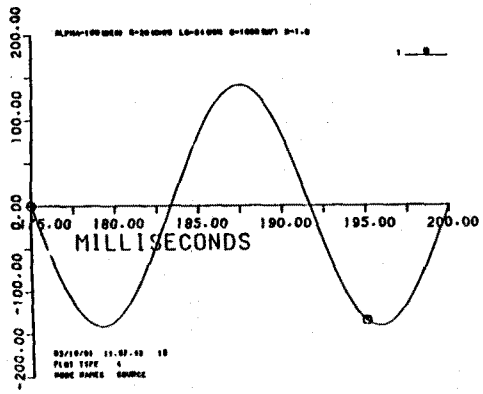


Fig.1 The Proposed Topology

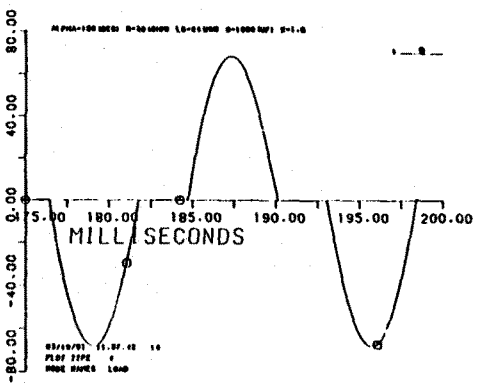
An example, inverted reactive power is maximum, when firing angle is 90 degree. At this time, capacitor voltage of rectifier part is nearly zero, therefore output voltage is nearly equal to source voltage.

The voltage drop of transformer is increased, as firing angle is increased, then clamped-sinusoidal output voltage is gradually decreased.

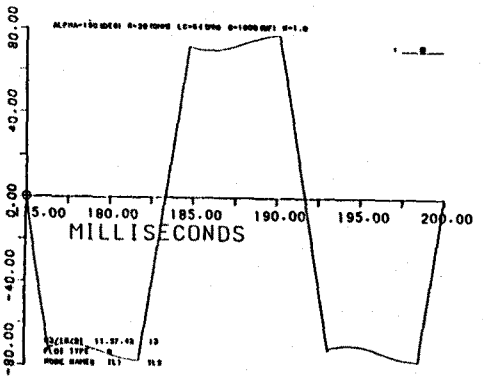
Fig.2 shows the simulation results of proposed circuit in steady state, when firing angle is 150 degree.



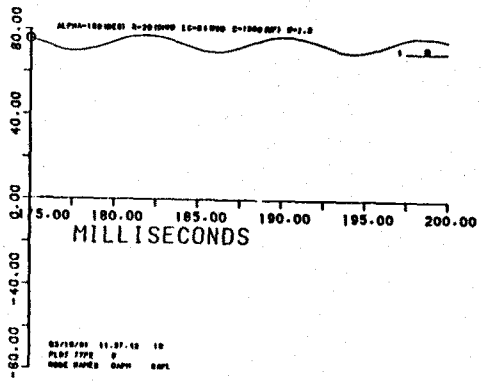
(a) Source Voltage



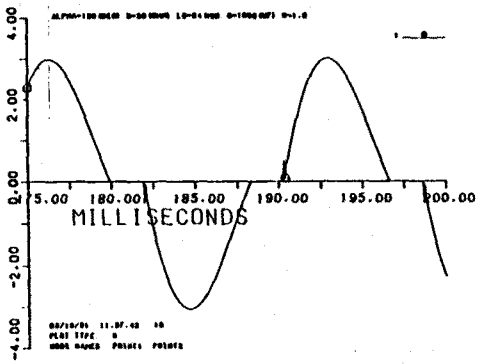
(b) Output Voltage



(c) Transformer Voltage



(d) Capacitor Voltage



(e) Inverting Current

Fig.2 Simulation Results (α = 150 deg)

Circuit parameters are as follows.

Vs = 100 $\sqrt{2}$ sin wt [volts]

RL = 20 [ohm]

C = 1000 [uF]

Lc = 64 [mH]

As is shown in fig.2 , harmonic components of output voltage is remarkably decreased compared with conventional phase control method.

Experimental Results

Fig.3 shows experimental results. There are waveforms of the source voltage, output voltage and gate signal.

It is agreed with simulation results and feasibility is verified experimentally.

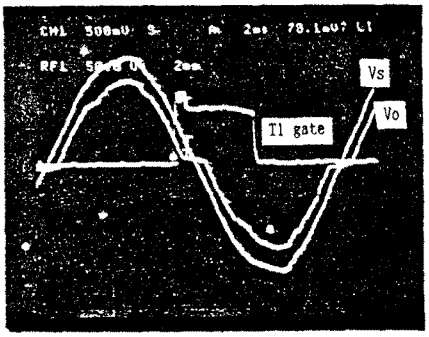


Fig.3 Experimental Results (α = 150 deg)

Conclusions

In this paper, the principles of proposed topology are described and verified by computer simulation. The characteristics of proposed topology are as follows.

- O The range of thyristor firing angle is form 90 to 180 degree for inverting operation.
- O The output voltage is varied from zero to source voltage.
- O The waveform of output voltage is clamped-sinusoidal, then harmonic components are remarkably decreased compared with conventional phase control method.
- O The feasibility of proposed topology is verified experimentally.

References

1. B.R.Pelly, Thyristor Phase-Controlled Converters & Cycloconverters, John Willey & Sons, 1971.
2. 在田保言 外 2人, 電力制御回路設計 ノラハラ, CQ 出版社, 1985.
3. 上山直彦, 다이리스터 制御 AC 모우터의 運轉과 保守, 機電研究社, 1978.
4. 上屋 外 3人, 位相制御型 PWM 交流電壓調整回路の 力率改善 パルス パターンに ついて
5. EMTP Rule Book, 1984.