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A DUAL TAP CHANGING STABILIZER WITH SUBCYCLIC AC SOFT SWITCHING

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***Abstract*: The ac voltage regulators with thyristor technology can be replaced by pulse width modulated (PWM) ac chopper, which has important advantages.In this paper, a dual-tap changing stabilizer is proposed. A dual-tap changing stabilizer, with a pulsewidth-modulation frequency and a new soft-switching technique achieved by two auxiliary small-power branches which act as bi-directional switches is proposed. It is based on the zero-current switch-off attainable several times in a half cycle under any combination of the current and voltage signs in the main taps. Consequently, the circuit combines high speed and low switching losses.The need for detecting the current zero crossing is eliminated by applying a specific switch activation schedule for each combination of the current and voltage signs of the main taps. The new method reduces the harmonic in the waveform and also it reduces the electromagnetic emission.**

Keywords: MOSFET, PWM Technique, Pspice/Simulink simulation

I. INTRODUCTION

Many applications, such as industrial heating, lighting control, soft start induction motors and speed controllers for fans and pumps requires variable ac voltage from fixed ac source. The phase angle control of regulators has been widely used for these requirements. It offers some advantages such as Simplicity and ability of controlling large amount of power economically. However, delayed firing angle causes discontinuity and plentiful harmonics in load current and a lagging power factor occurs at the ac side when the firing angle is increased.The main attribute of the ac chopper topology is the fact that it generates an output ac voltage larger or lower than the input ac one, depending on the instantaneous duty-cycle. This property is not found in the classical ac chopper, which produces an ac output instantaneous voltage always lower than the input ac voltage. Traditionally phase angle control and integral cycle of thyristors are used in ac voltages regulators. They suffer from inherent disadvantages such as retardation of firing angle, lagging power factor at input side and high lower-order harmonic contents in both load and supply voltages and currents. In order to avoid these disadvantages MOSFET's in ac chopper controller is used.

With the increased availability of power MOSFET's and insulated gate bipolar transistors, a new generation of simple choppers for ac inductive loads is foreseen. These power semiconductors ease the use of forced commutation of thyristor switches to improve the supply power factor, even with highly inductive loads[1]. The ac voltage controllers with thyristor technology can be replaced by pulse width modulation ac choppers, which have several advantages.

An optimal control strategy for selecting firing and commutation angles in pulse width modulated single-phase ac/ac chopper, minimizes output voltage harmonic distortion through numerical techniques, and cab also simultaneously eliminate certain chosen harmonics[2]. Best results are obtained in this method, but the harmonics are not completely eliminated.

Steady-state modeling analysis and performance of transistor controlled ac power conditioning systems deals with the transistor controlled ac voltage regulators, operating at medium-to-high frequency chopping mode and utilizing PWM technique, which appear to offer attractive alternatives to thyristor controlled regulators in low and medium power applications in ac power conditioning systems[3].

Pulse Width Modulated Insulated Gate Bipolar Transistor (IGBT) ac chopper proposes a new circuit for three-phase voltage controller constructed with IGBT's. Traditionally such equipment uses thyristors as switching elements, whose draw back comes from its only possible control method:"firing control". It allows PWM control, providing much better properties [4].

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The similar control is also possible by using MOSFET. In this paper PWM technique is used for triggering the MOSFET. Different types of PWM techniques are available[5].In this paper even PWM technique is used.

The PWM ac chopper offers several advantages such as sinusoidal input current with near unity power factor.

However, to reduce the filter size and improve the quality of output regulator the switching frequency should be increased. This causes high switching loss. Another problem is the commutation between the transferring switch with freewheeling switch. It cause the current spike if the both switches are turned on at the same time (short circuit), and the voltage spike if the both switches are turned off (no freewheeling path) [5]. To avoid these problems, RC snubbers are used however; this increases the power loss in the circuit and is difficult, expensive, bulky and inefficient for high-power applications.

II. OVERVIEW OF AC STABILIZER

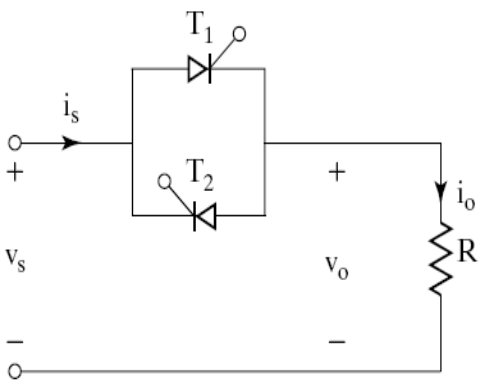

Figure. 1. Basic AC Chopper

In Fig.1 The thyristor T_1 is forward biased during the positive half cycle of the input supply voltage. The thyristor T_1 is triggered at a delay angle of $'\alpha'$ $\left(0 \le \alpha \le \pi \text{ radians}\right)$. Considering the ON thyristor T_1 as an ideal closed switch the input supply voltage appears across the load resistor R_L and the output voltage $v_O = v_S$ during $\omega t = \alpha$ to π radians. The load current flows through the ON thyristor T_1 and through the load resistor R_L in the downward direction during the conduction time of T_1 from $\omega t = \alpha$ to π radians.

At $\omega t = \pi$, when the input voltage falls to zero the thyristor current (which is flowing through the load resistor R_L) falls to zero and hence T_1 naturally turns off . No current flows in the circuit during $\omega t = \pi$ to $\left(\pi + \alpha\right)$.

The thyristor T_2 is forward biased during the negative cycle of input supply and when thyristor T_2 is triggered at a delay angle $\left(\pi + \alpha\right)$, the output voltage follows the negative halfcycle of input from $\omega t = \left(\pi + \alpha\right)$ to 2π. When T_2 is ON, the load current flows in the reverse direction (upward direction) through T_2 during $\omega t = \left(\pi + \alpha\right)$ to 2π radians. The time interval (spacing) between the gate trigger pulses of T_1 and T_2 is kept at π radians or 180^0. At $\omega t = 2\pi$ the input supply voltage falls to zero and hence the load current also falls to zero and thyristor T_2 turn off naturally.

III. OPERATION OF THE AC STABILIZER WITH COMPENSATING TRANSFORMER

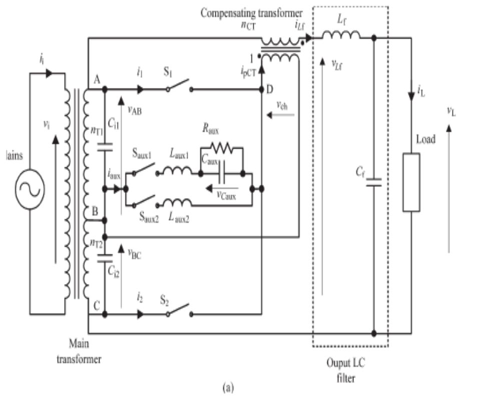

Figure.2. AC Stabilizer with compensating Transformer

The series connected switch S across the diode bridge is used periodically to connect and disconnect the load to the supply i.e., it regulates the power delivered to the load. The parallel switches S_1 and S_2 provide a freewheeling path for the load current to discharge the stored energy of the inductance when the series switch is turned-off. The reason to use a diode in series with each parallel switch is to enable it to be used in a circuit where a reverse voltage is encountered and to complete the freewheeling current paths.

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Here MOSFET's are used as controlled switches and gating of these switches is based on equal Pulse Width Modulation (PWM) technique or constant Pulse Width Modulation method.

In pulse width modulation control, the converter switches are turned-on and turned-off several times during a half-cycle and varying the width of the pulses controls the output voltage. Comparing a triangular wave with a dc signal generates the gate signals. The lower-order harmonics can be eliminated or reduced by selecting the number of pulses per half-cycle.

IV.OPERATION OF THE PROPOSED CIRCUIT

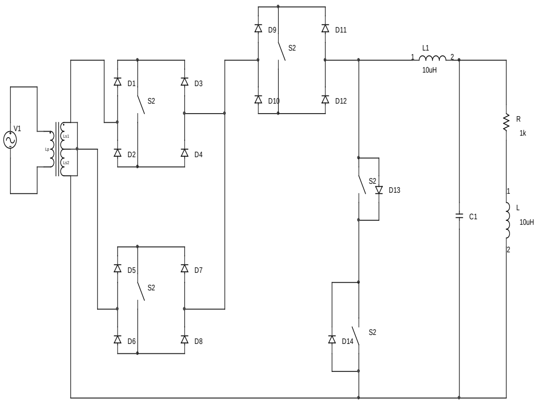


Figure.3. AC Stabilizer without compensating Transformer

The series connected switch S across the diode bridge is used periodically to connect and disconnect the load to the supply i.e., it regulates the power delivered to the load. The parallel switches S_1 and S_2 provide a freewheeling path for the load current to discharge the stored energy of the inductance when the series switch is turned-off. The reason to use a diode in series with each parallel switch is to enable it to be used in a circuit where a reverse voltage is encountered and to complete the freewheeling current paths.

Here MOSFET's are used as controlled switches and gating of these switches is based on equal Pulse Width Modulation (PWM) technique or constant Pulse Width Modulation method.

V. HARDWARE DIAGRAM

VI. SIMULATION RESULTS AND ANALYSIS

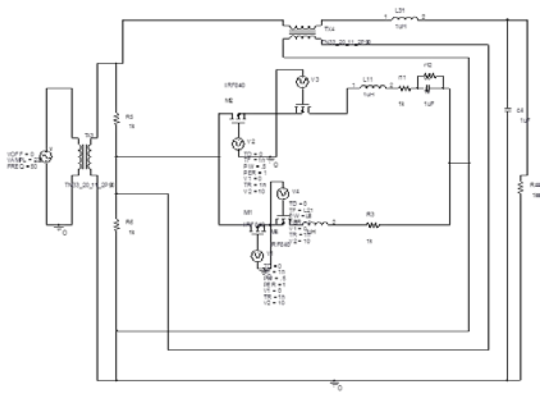
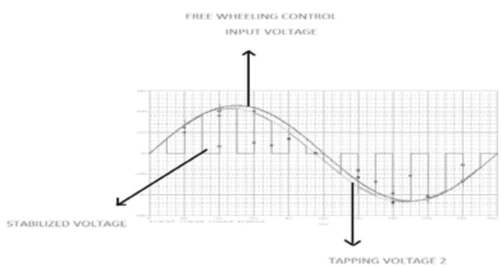


Fig.3. (a)



(b)

Figure. 3. (a) AC stabilized circuit with compensating transformer (b) Waveform of AC stabilized circuit with compensating transformer

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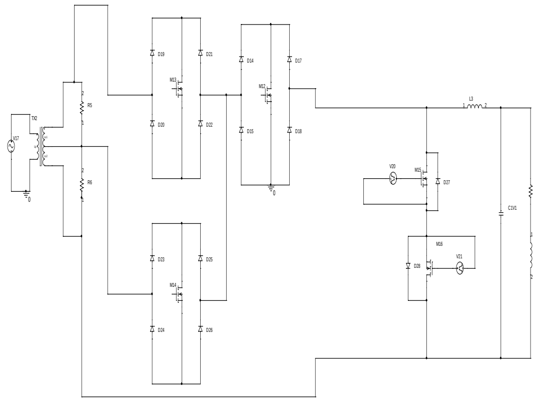
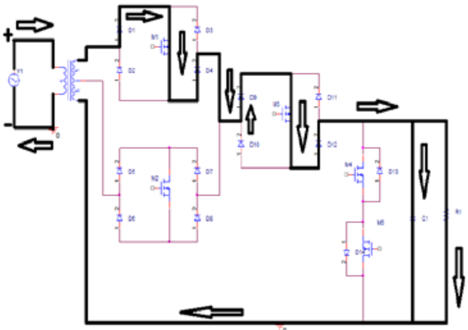
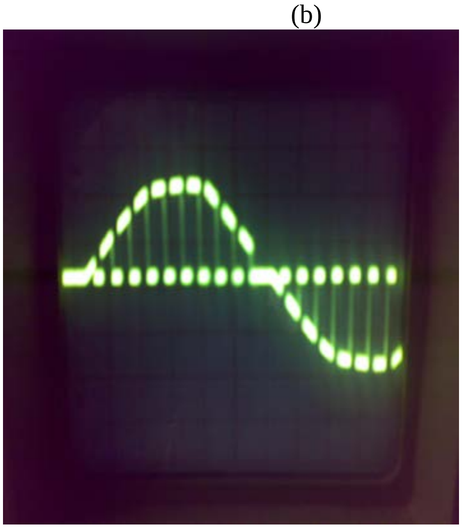


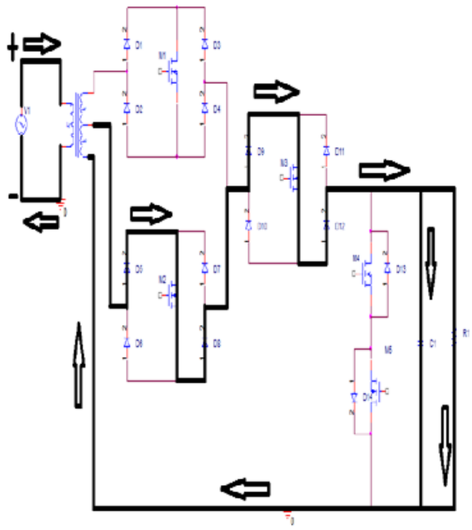
Fig.4.(a)



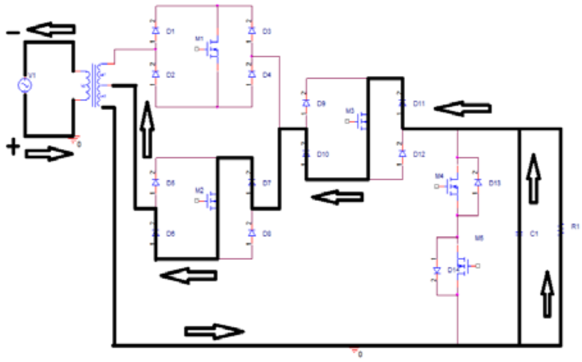
(b)



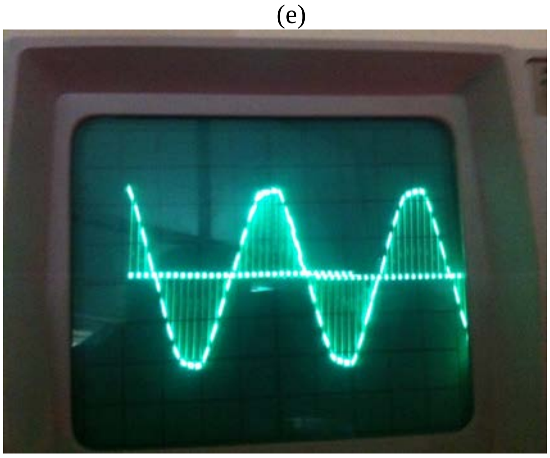
(c)



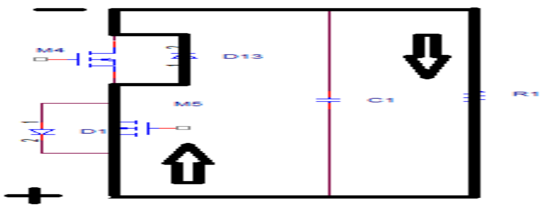
(d)



(e)



(f)



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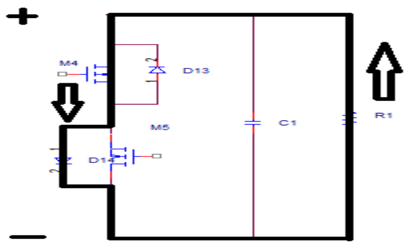

(g)

Figure. 4. (a) AC stabilized circuit without compensating transformer

(b) Mode 1:M1-Conduct(D1 & D4) M3-Conduct (D9 & D12) C1-conduct (c) Output waveform of tap1
(d) Mode 2:M1-Conduct(D2 & D4) M3-Conduct (D10 & D11) C1-conduct
(e) Mode3:M2-Conduct(D5 & D8) M3-Conduct (D9 & D12) C1-conduct Mode 1:M1-Conduct(D1 & D4) M3-Conduct (D9 & D12) C1-conduct
(f) Mode 4:M2-Conduct(D6 & D7) M3-Conduct (D10 & D11) C1-conduct (g) Output waveform of tap2

In pulse width modulation control, the converter switches are turned-on and turned-off several times during a half-cycle and varying the width of the pulses controls the output voltage. Comparing a triangular wave with a dc signal generates the gate signals. The lower-order harmonics can be eliminated or reduced by selecting the number of pulses per half-cycle.

The comparison of the results of existing and proposed system indicates the resultant voltage remains the same in both the systems. In proposed system by replacing the compensating transformer with soft switching device, the electromagnetic stress and harmonic levels are reduced considerably. In future harmonic analysis may be done using fast Fourier transform.

VI.CONCLUSION

In this paper, a PWM AC CHOPPER with soft switching (without compensating transformer) was successfully simulated in Pspice and Validation and comparison of simulation results with experimental results are also given.From the results, it is observed that the proposed system with soft switching reduce the electric stress, electromagnetic emission and harmonics in the output waveform.

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