Subcyclic Switching and Symmetrical Chopper with Tap Changing

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Abstract- Dual-Tap Chopping Stabilizer is an AC voltage regulator with dual tap changer. AC regulators based on tap changers are implemented with SCR's and TRIACs are widely used for their robustness. With thyristor soft switching, commutation losses are reduced to nearly zero, but it allows only supercyclic commutation, i.e, only one commutation per cycle is possible. By replacing thyristors with high power transistors and gate turn off thyristors, it is possible to achieve several tap changes in one half cycle ,i.e, subcyclic commutation.

In this paper an AC chopper is designed with MOSFET switches to achieve subcyclic commutation. Thus subcyclic switching is achieved. A freewheeling circuit is added in the load side. The freewheeling circuit has the following advantages:

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I. INTRODUCTION

A. Dual tap chopping stabilizer

A stabilizer is an AC voltage regulator which stabilizes the voltage according to the need. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It may use an electromechanical mechanism, or passive or active electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. With the exception of passive shunt regulators, all modern electronic voltage regulators operate by comparing the actual output voltage to some internal fixed reference voltage. Any difference is amplified and used to control the regulation element in such a way as to reduce the voltage error. This forms a negative feedback control loop; increasing the open-loop gain tends to increase regulation accuracy but reduce stability. In dual tap chopping stabilizer, the voltage regulator works under a permanent pulse width-modulation switching pattern. Two tapings are taken from the transformer connected to the supply.

B. Conventional method

Conventional method of dual tap chopping stabilizer employs SCRs for switches. They implement upercyclic soft switching. In supercyclic switching, the switches can be switched ON and OFF only after a half cycle. It requires a commutation circuit and commutation capacitor for zero crossing.

Disadvantages

- zero crossing detection is required.
- switching after one half cycle.
- commutation losses.
- No control with the gate.

II. PROPOSED METHOD

A. Subcylic ac soft switching

Soft switching is a technique where no mechanical switches are used. Instead the turn on and turn off is carried out using power electronic devices. Thyristors were used to carry out this which allows supercyclic switching. But if high level transistors like IGBTs and MOSFETs are used, subcyclic switching is possible. In subcyclic switching, no zero crossing detection is required and moreover the device can be turned off and on several times within a half cycle. The commutation losses are also eliminated.

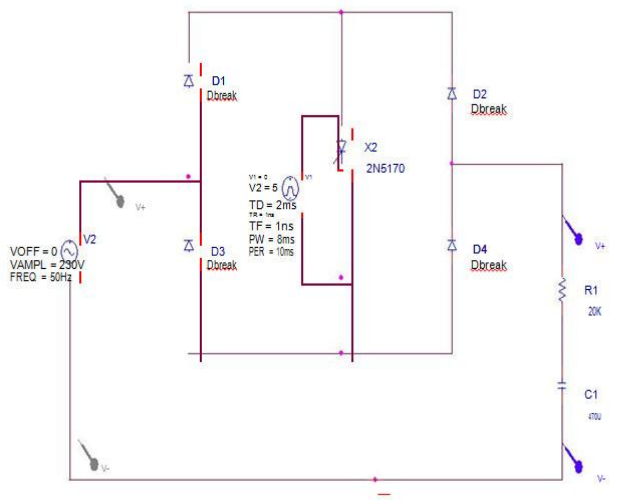


Fig1 Conventional circuit of an AC voltage regulator

B. Circuit

In this paper a design of dual tap changing stabilizer with subcylic AC soft switching is presented. Two tappings are taken from the transformer connected to the supply. The chopper circuit is built with four diodes and a MOSFET. Thus subcyclic AC switching is achieved. Two tapping, one for 110v and the other for 230v is taken with the help of a chopper circuit acting as a switch. When the upper switch is on, the load is connected to 230v input. When the lower switch is on, the load is connected to 110v input. A freewheeling circuit is included before the load.

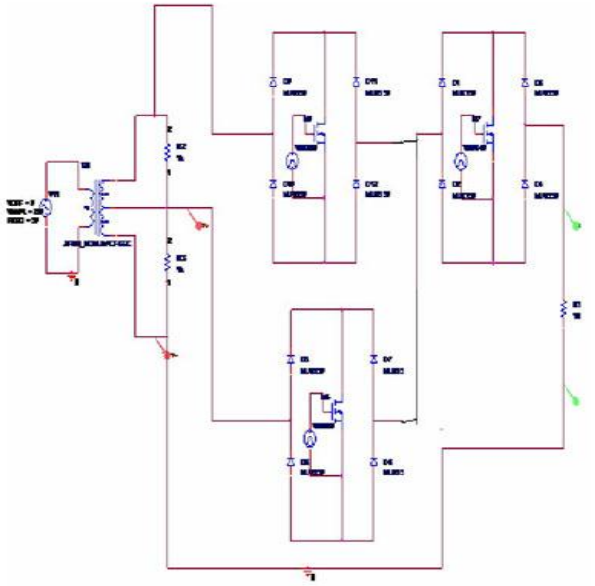


Fig 2 Proposed circuit

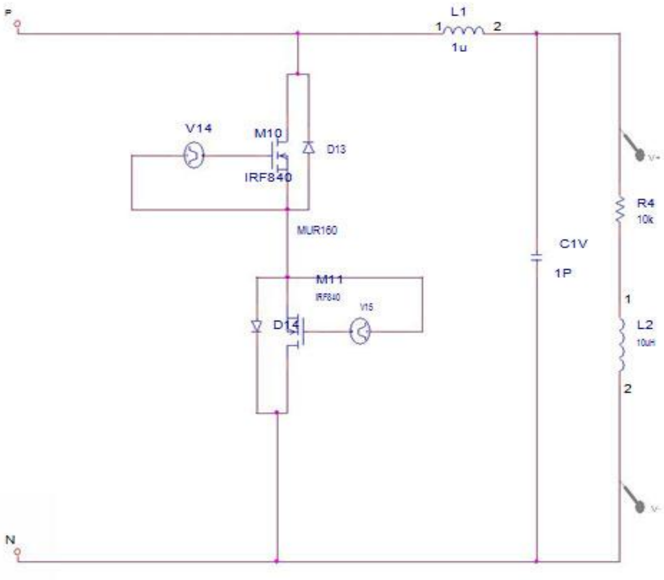


Fig 3 Freewheeling circuit

ADVANTAGES OF FREEWHEELING CIRCUIT

- Prevents The Sudden Reversal Of Current
- Avoid Peak Currents And Transients

III. Modes Of Operation

A. Mode 1:230v input, positive cycles

In this mode the upper switch M1 is turned on. The diodes D1 and D2 conduct as they are forward biased. The diodes D2 and D3 are off. Both the tappings of the transformer are included. So the full input voltage 230v is available. The chopper switch M3 is also turned on to stabilize the voltage. The diodes D9 and D12 conduct for the positive half cycle. The return path is through the ground

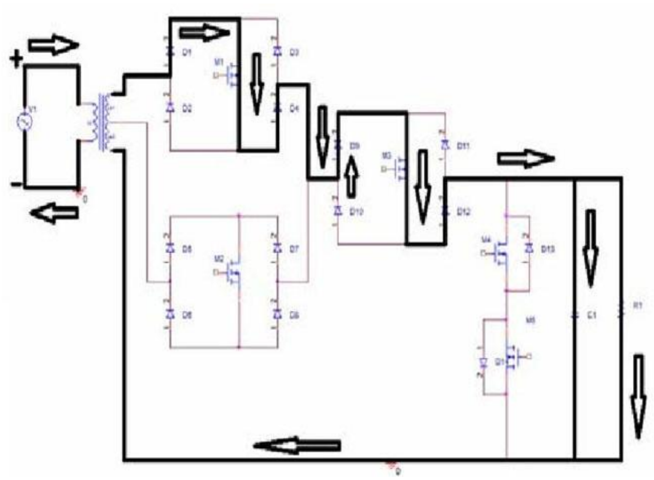


Fig 4 Mode 1

B. Mode 2 : 230v input, negative cycle

This mode is similar to mode 1 as it includes 230v. but here the 230v appears as negative half cycle. This achieved by the conduction of diodes D2 and D4.The chopper switch M3 is also turned on to stabilize the voltage. The diodes D10 and D11 conduct for the positive half cycle. The return path is through the ground

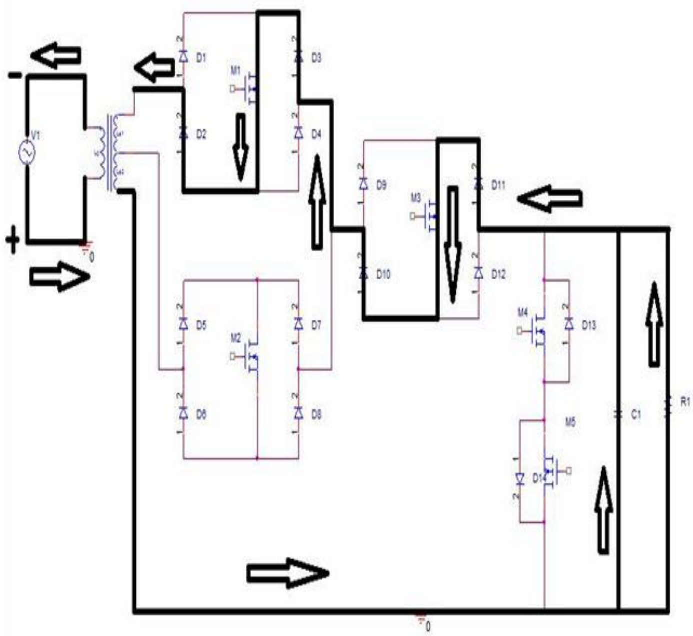


Fig 5 Mode 2

A. Mode 3 : 110v input , positive cycle

In this mode the lower switch M2 is turned on. The diodes D5 and D8 conduct as they are forward biased. The diodes D6 and D7 are off. One half of the tappings of the the transformer is included. So the input voltage of 110v is available. The chopper switch M3 is also turned on to stabilize the voltage. The diodes D9 and D12 conduct for the positive half cycle. The return path is through the ground.

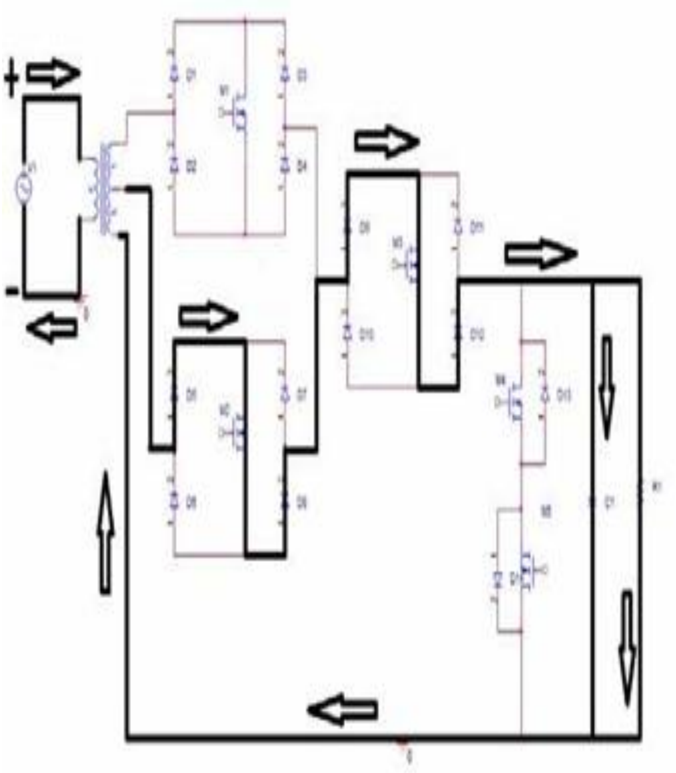


Fig 6 Mode 3

B. Mode 4: 110v input, negative cycle Table Type Styles

This mode is similar to mode 3 as it includes 110v. But here the 110v appears as negative half cycle. This achieved by the conduction of diodes D6 and D7 . The chopper switch M3 is also turned on to stabilize the voltage. The diodes D10 and D11 conduct for the positive half cycle. The return path is through the ground.

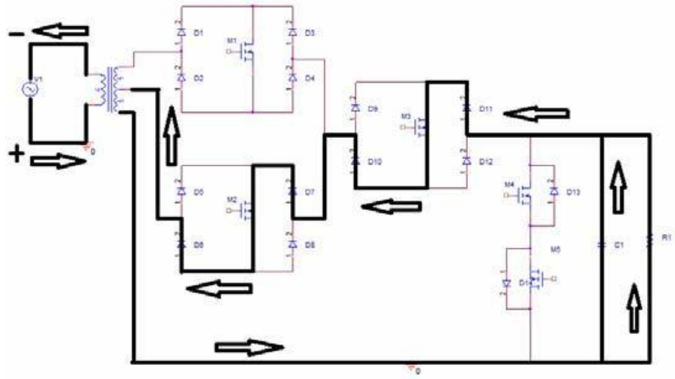


Fig 7 Mode 4

C. Freewheeling circuit operation: positive cycle

During positive half cycle the switch M5 is turned on. The diode D13 which is inbuilt in the MOSFET M4 conducts as it is forward biased. The sudden reversal of current is bypassed through the freewheeling circuit.

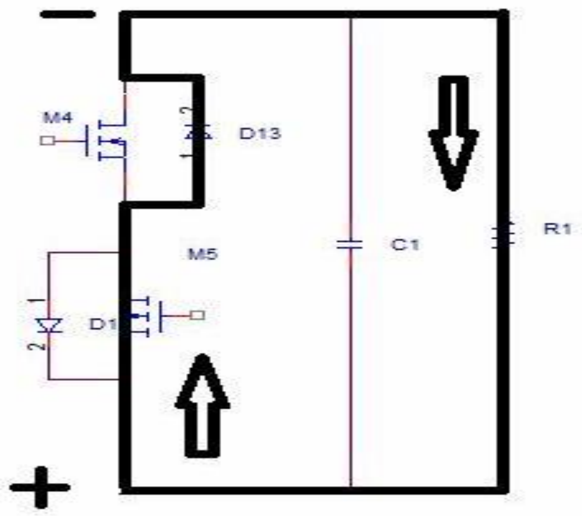


Fig 8. Freewheeling (positive cycle)

F. Freewheeling circuit operation: negative cycle

During negative half cycle the switch M4 is turned on. The diode D14 which is inbuilt in the MOSFET M5 conducts as it is forward biased. The sudden reversal of current is bypassed through the freewheeling circuit.

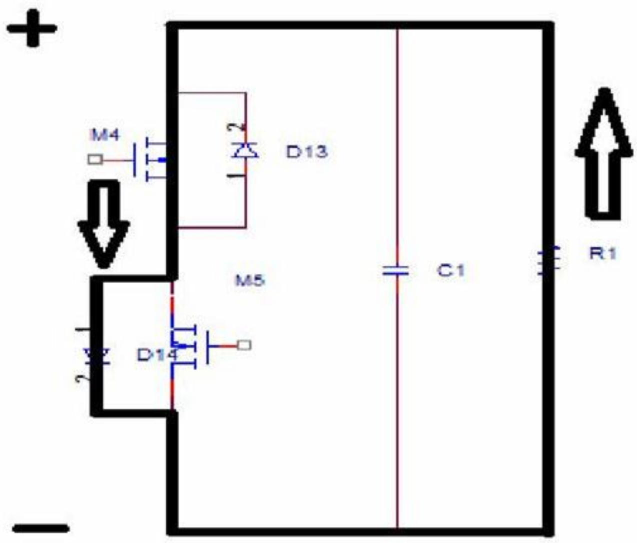
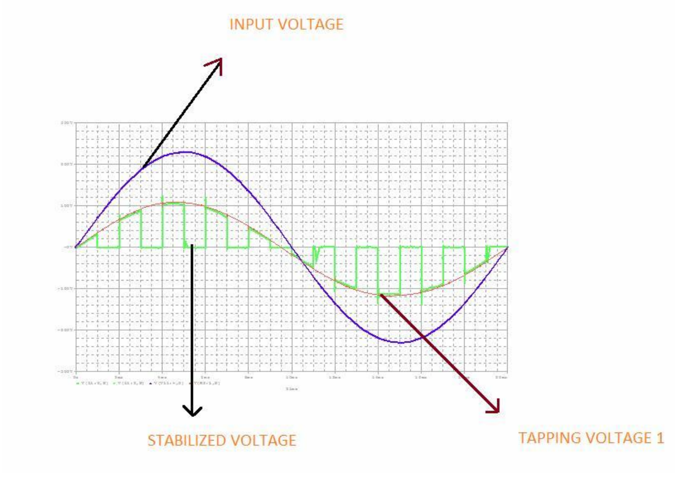
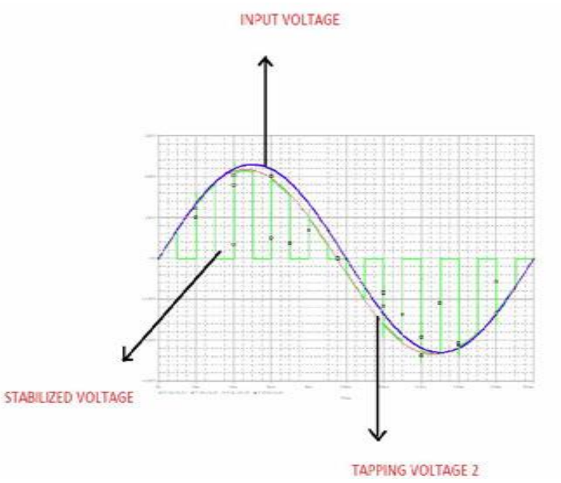


Fig 9 Freewheeling (negative cycle)

IV. SIMULATION RESULTS



110v output



230v output

V. CONCLUSION

A dual tap chopping stabilizer was taken into consideration and simulated using Pspice simulator. MOSFETs were used as switching devices. A transformer was designed to get the two taps of operating voltage. MOSFETs are used in combination with the diodes to get the required working voltage. Here AC soft switching with subcyclic operation was proposed. Because of more periods, chopping of the voltage was achieved. By using MOSFETs, the switching losses were minimized to near zero. No zero crossing detection was required. A freewheeling circuit was added to the chopper to prevent the sudden current reversal when operating with a inductive load. It also prevents peak currents and transients.

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