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I. INTRODUCTION

The conventional rectifier [1] which is popularly referred as Unity Power Rectifiers (UPR)/ Boost rectifier (BR) suffers from various limitations such as low power factor, high ripple content on load voltage and increase in harmonic contents in source current due to non-linear load current that results in significant increase of total harmonic distortion (THD). The main objective of conventional SMR (i.e. shown in Fig.1) is to eliminate these problems so as to maintain unity pf, sinusoidal input current, constant dc voltage and restricted harmonic distortion based on IEEE std. To avoid the separate operation for discontinuous current mode (DCM) and continuous current mode (CCM), a mixed-mode operation [2] is proposed for wide-range of load variation. Since the ripple content on output capacitor voltage and harmonic contents in input ac current are prime concern, the authors [3] presented a robust technique to get rid of these problems. In SMR, the power flow is unidirectional and the circuit is to be operated as boost switch which enables the capacitor to keep the voltage slightly greater than peak of source voltage. But in order to double the level of capacitor voltage with respect to input voltage, a new topology [4] is proposed by Y.Neba and et.al. All these SMRs operate for resistive load, but Patil and et.al[5] changed this resistive load to induction motor to study its effect upon SMR. The mixed-mode operation [2], which has some limitations, has been overcome by modifying the SMR [6]. The topologies used [1-8] use boost inductor on dc side. So this suffers from following demerits.

(i) The inductor in dc side of conventional SMR gets saturate when it handles more current. For this it needs advanced control or replacement of new inductor.

(ii) The SMR is provided filter either at input /output except the boost inductor.

In the present paper, a modified SMR that includes two additional switches in one leg is proposed. This modified SMRis shown in close-loop circuit diagram shown in Fig. 2. Though the modified SMR needs four diodes and two switches as compared to five diodes and one switch in case of conventional SMR, but it overcomes the above demerits of the conventional SMR. No of devices conducting in modified SMR is two instead of three in case of conventional SMR. So the conduction losses in modified SMR is less as compared to conventional SMR.

II. HYSTERESIS CURRENT CONTROL TECHNIQUE

This technique, which is also known as tolerance band control (i.e., shown in Fig.2), is most common method used for SMR and easier to implement. This scheme is meant for low power application. In this method, the reference current signal is generated from the source voltage. This reference current is allowed to pass through a hysteresis band ($\pm\delta i$) so that actual current must follow within the band. This can be understood from the following diagram. When the source current hits lower band, the switch is on. The rate of rise current is positive. This current will go on increase within this band till it hits upper limit. At this moment the switch is made off. Now the load voltage appears across the source and the rate of change current is negative. In this manner, the source current has to follow the reference current within its hysteresis band. If this band is reduced, the switching frequency of the device will be increased. As a result, the source current will be more approximately sinusoidal and in phase with source voltage. This switching frequency is decided based upon the safe operation of the device because of limit in safe operating area. Lower the band means higher the switching frequency.

III. CLOSE -LOOP OPERATION

The close-loop circuit diagram is shown in Fig. 3. The closed loop voltage control scheme is needed to maintain the power balance between load and the source. The reference voltage (Vdc-ref) is compared with the actual output capacitor voltage (Vc) and the error is processed through PI-controller. The output of PI controller in association with input voltage is used to produce sinusoidal reference current (Is^*). The reference current is compared with actual source current and the error is processed through hysteresis controller and the firing circuit so as to generate signals for switching-on and switching-off of the devices. The switching frequency is varying on both half cycles.

IV. SIMULATION RESULTS

The closed loop control system of Modified SMR is simulated using MATLAB/ Simulink. A hypothetical load resistance is assumed for simulation. The source voltage is 230V rms and 50 Hz. The ac side boost inductor and dc capacitor are considered as 2mH and 10000μF respectively. The reference voltage of the capacitor is fixed at 400V. Simulation results are presented in Figs. 4 to 6. Figure 4 shows the waveforms of transient response of capacitor voltage, when the controller is made effective at t=0.1 sec. It is found that the controller takes 0.4 sec to retain its reference value. In Fig. 5, it shows the input ac supply voltage, source current and the ac voltage at the input of SMR under steady-state condition. It is also found that the input current is in phase with input supply thus resulting unity pf.. In order to check the harmonic level at the input current, the level of total harmonic distortion (THD) is studied using the block available in MATLAB/Simulink. Fig. 6 shows the harmonic analysis of the input current. The dominant harmonic components are 3rd, 7th and 9th when it is investigated below 500 Hz. The 3rd, 5th and 7th harmonic levels are 1.6%, 0.85% and 0.6% respectively. The total harmonic distortion (THD) is found to be within IEEE standard of current distortion.

V. CONCLUSION

The proposed modified SMR was simulated successfully with the help of MATLAB/Simulink. The hysteresis control technique was utilized to actively shape the input current. Switching losses remain same in either cases, because the single switch in conventional SMR operates during both half cycles, whereas in modified SMR, one of the switches operates in one half cycle and other one in next half cycle. As the modified SMR contains less no of devices in its conduction path during both on and off period compared to conventional one, so it is more advantageous. Not only that this also eliminates use of filter at its input and avoids higher value of inductor in case of larger power handling. The total harmonic distortion was investigated and found to be restricted to less than 2.2%.

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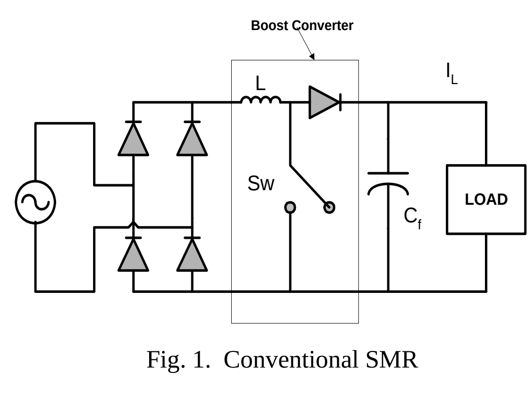

Fig. 1. Conventional SMR

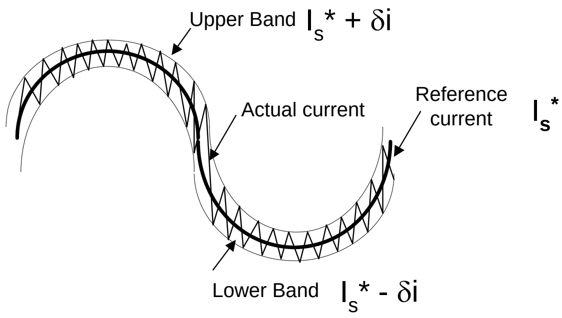

Fig. 2 : Hysteresis control

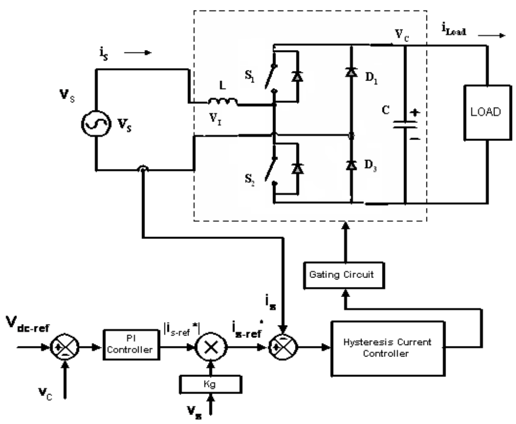

Fig. 3. Closed loop control

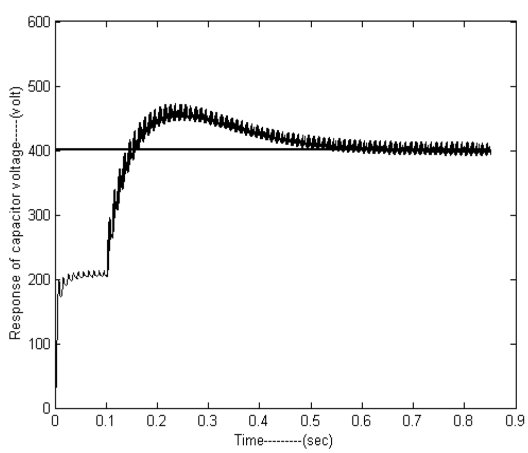

Fig.4: Response of capacitor voltage when the controller is activated at t=0.1 sec and reference is 400V

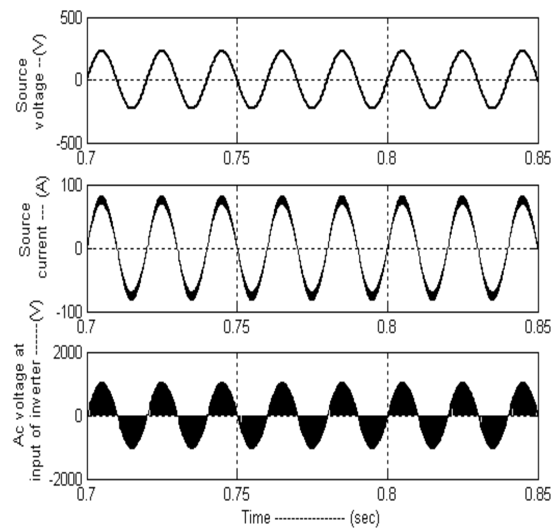

Fig. 5: Figs showing source voltage, source current, inverter input voltage under steady-state conditions

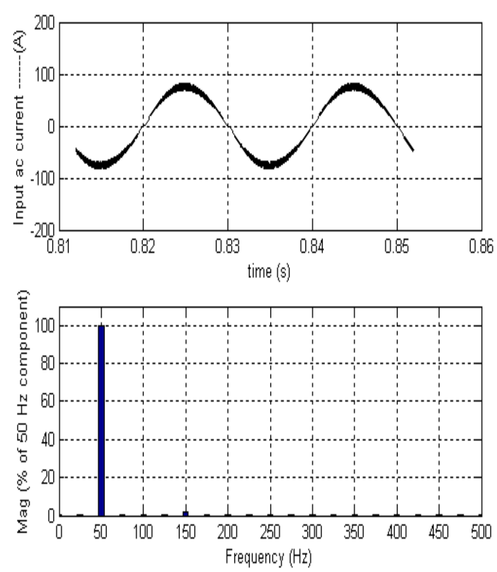

Fig. 6. Harmonic analysis for two cycle of input current Top: source current; Bottom: Harmonic spectrum

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