A Novel Interleaved Control Strategy for Three Level Switch Mode Rectifier

RESHMA
M.Tech Student,
Department of EEE,
SSJEngineeringCollege.

CH VINAY KUMAR
Associate Professor
Department of EEE,
SSJEngineeringCollege.

Abstract: Multiloop Interleaved Control (MIC) is proposed, and it is combined with conventional multiloop controland the interleaved pulsewidth modulation scheme. The averagebehavior of the interleaved three-level switch-mode rectifier(SMR) behaves similar to the conventional boost-type SMR eventhough two capacitor voltages are imbalanced. It implies thatconventional multiloop control can be applied to the interleavedthree-level SMRs to achieve the desired power factor correction function.
Index Terms—Interleaved control, Lithium- Ion Battery, three-level boost switchmode rectifier (SMR).

I. INTRODUCTION

THE QUALIFIED ac/dc conversion must meet the functionsof input current shaping and output voltage regulation.The boost-type switch-mode rectifier (SMR), including adiode rectifier and a boost converter, is often used to perform the qualified ac/dc conversion [1]–[3]. In addition, the multiloopcontrol with the inner current loop and the outer voltage loopis often used to generate a switching signal in boost-type SMR.

However, multiloop control needs to sense three signals: currentsignal and input and output voltage signals.Recently, to reduce the number of feedback signals, manyvoltage sensorlesscontrols (VSCs) [4]–[7] and current sensorlesscontrols (CSCs) [8]–[10] for boost-type SMR have been
proposed in the literature. The summary of feedback signals for sensor less controls is tabulated in Table I. It is clear that fewerfeedback signals were used in sensorless control except the onin due to the additional dc load current sensing.

II. PROPOSED TOPOLOGY

The three-level boost converter is shown in Fig. 1 wheretwo capacitors are connected across the switches, respectively Thus, each switch needs to withstand only a half output voltage.In addition, the inductor voltage in the three-level boostconverter has three levels, but the inductor voltage intheconventional boost converter has only two levels.Therefore, the three-level boost converter is able to yieldsmaller inductor current ripple than the conventional boost converter.

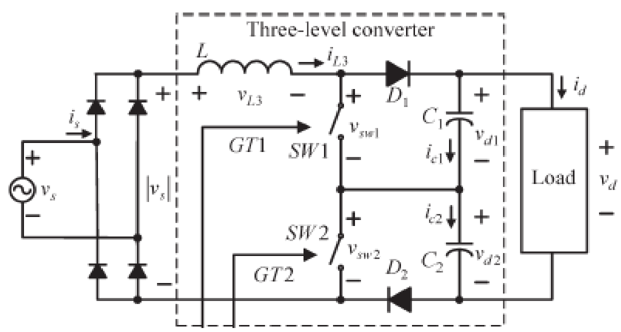


Fig. 1. Three-level SMR

It follows that three-level converters are often used in theapplications, such as the high-voltage–ratio dc/dc conversion and the wide input voltage range, particularlyin the fuel cell applications and the grid-connectedapplications .

Additionally, the high-withstanding-voltage semiconductorswitches often have larger drain–source resistances than thelow-withstanding-voltage ones. Thus, the three-level converterhas the advantages of low voltage stress, small inductor currentripple, and low switching loss .In Fig. 1, the three-level SMR was obtained by connectingthe diode rectifier with the three-level converter .

In the three single-phase three-level SMRs are in Deltaconnection to achieve the three-phase PFC function with theability of redundancy.

The control methods for the three-level SMR (ac/dc application)can be found in where gate signals *GT1* and*GT2* are generated from the lookup table with inputs *H*1, *H*2,and *H*3. In this paper, the average behavior of a three-level SMRunder the interleaved pulsewidth modulation (PWM) scheme(i.e., interleaved three-level SMR) is derived. Theinteresting result shows that the interleaved three-level SMRbehavessimilar to a conventional boost-type SMR even when thetwo capacitor voltages are imbalanced. It means that the multiloopcontrol and the interleaved PWM scheme can be integratedto achieve the desired PFC function without an additional voltagebalancing loop. Thus, the proposed multiloop interleavedcontrol (MIC) is simpler than the control method in Fig. 1.

From the provided simulation and experimental results, theproposed MIC is able to achieve PFC functions, and in particular,the three-level SMR in ac/dc application is able totake several seconds to balance the capacitor voltages withoutthe voltage balancing control loop. However, because the timetaken to balance the voltages is long, the voltage balancing loop
is sometimes required.

III.CONTROL STRATEGY

The proposed MIC shown in Fig. 2 combines the conventionalmultiloop control, the feedforward loop, and the interleavedPWM scheme. Both the voltage controller and the currentcontroller are proportional–integral-type controllers. Two gatesignals *GT*1 and *GT*2 are generated from the comparisons ofcontrol signal *v*cont3 and two unit sawtooth signals *v*tri1 and*v*tri2, respectively. It is noted that the twosawtooth signals haveunit amplitude and identical period *Ts*; however, there is a 180◦phase difference between them. Both duty ratios of switches*SW*1 and *SW*2 are equal to the MIC control signal *v*cont3.

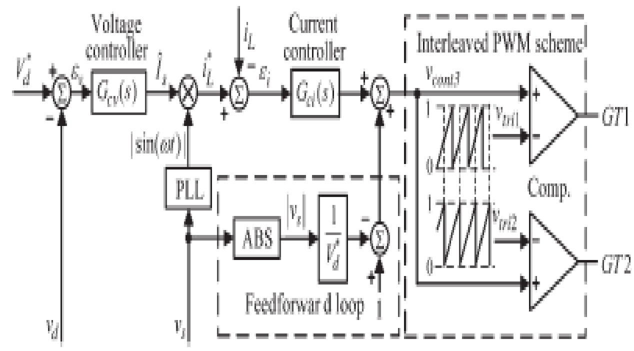
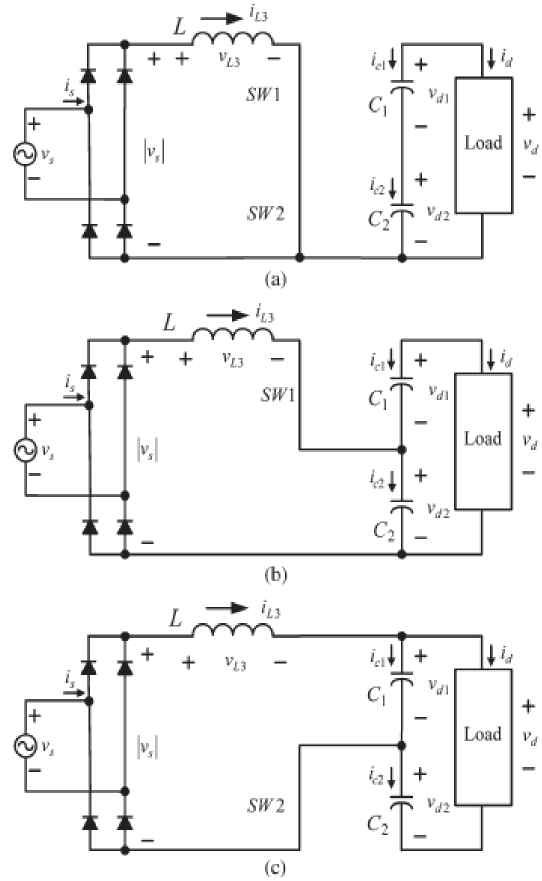
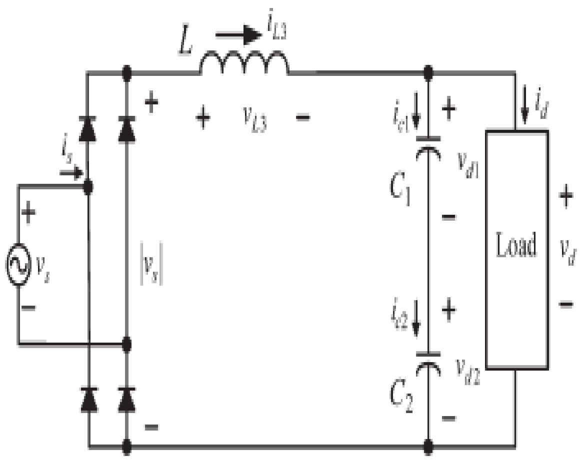


Fig. 2. Proposed MIC for three-level SMR.





(d)

Fig. 3. Possible switching states in the interleaved three-level SMR. (a) State 1.
(b) State 2. (c) State 3. (d) State 4.

IV.SIMULATION RESULTS

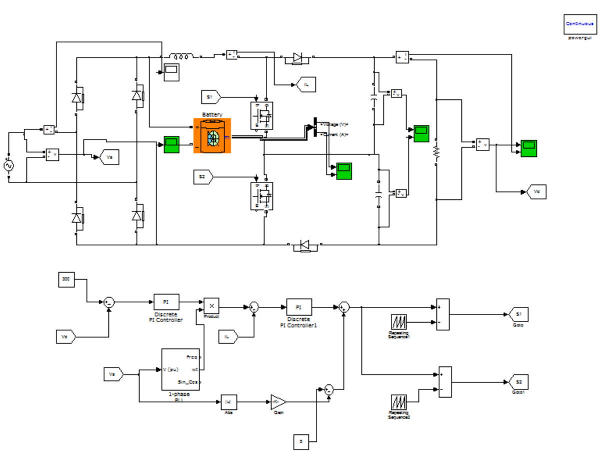


Fig 4. Simulation Circuit with battery

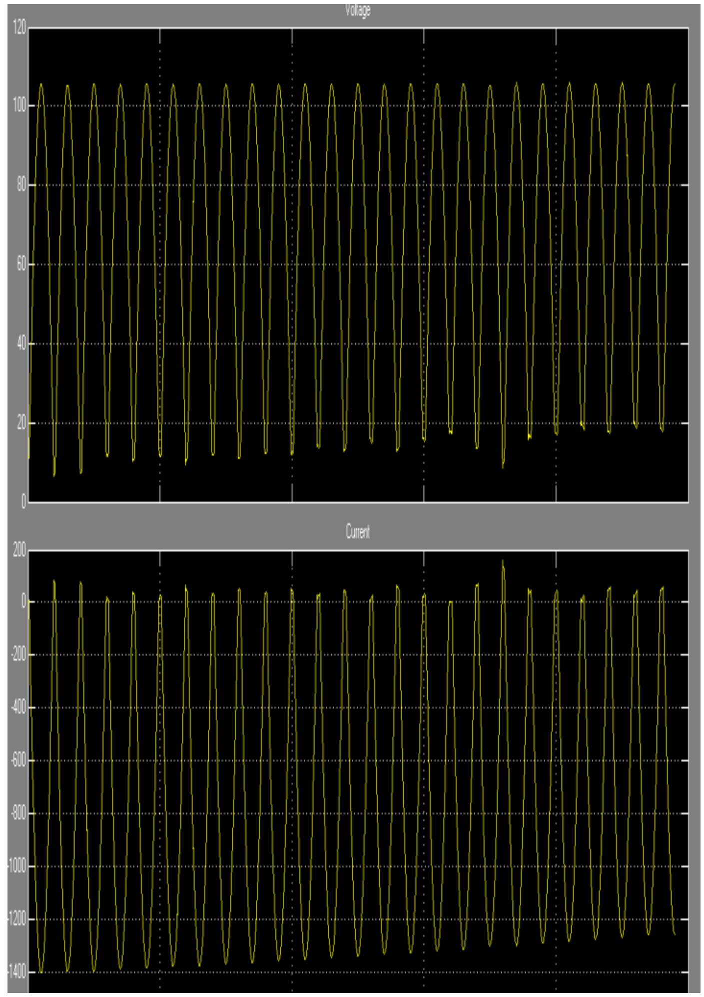


Fig 5. Battery voltage & current

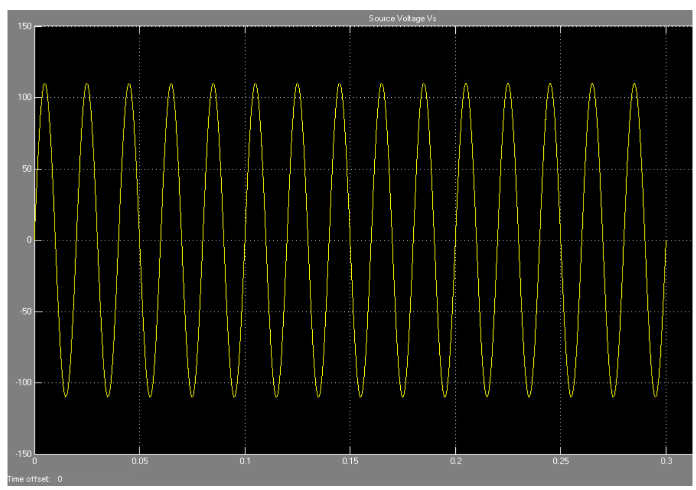


Fig 6. Source Voltage

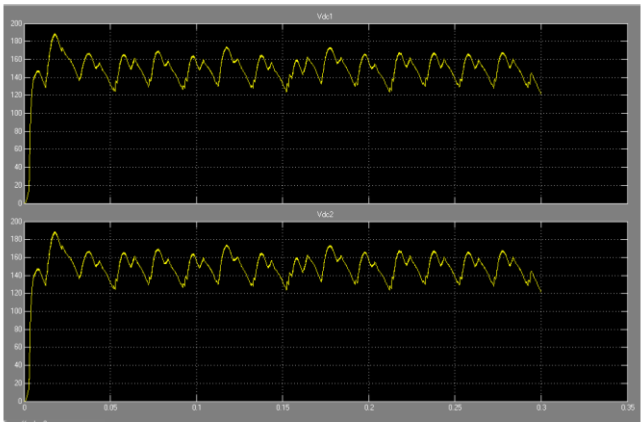


Fig 7. Vdc1 & Vdc2 Capacitor Voltages

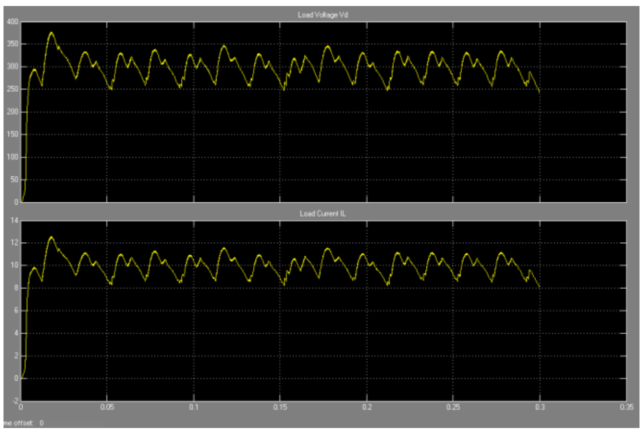


Fig 8. Load Voltage & Current

V.CONCLUSION

In this paper, the results show that the interleaved three-levelSMR with the interleaved PWM scheme behaves similar to aconventional boost-type SMR. Its performance of the currentshaping function does not degrade even when the two capacitorvoltages are imbalanced. The MIC for the three-level SMR inac/dc applications has been proposed simulation results have ben proved.

REFERENCES

[1] B. Singh, B. N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, andD. P. Kothari, "A review of single-phase improved power quality AC–DCconverters," *IEEE Trans. Ind. Electron.*, vol. 50,no. 5, pp. 962–981,Oct. 2003.

[2] J. C. Crebier, B. Revol, and J. P. Ferrieux, "Boost-chopper-derived PFCrectifiers: Interest and reality," *IEEE Trans. Ind. Electron.*, vol. 52, no. 1,pp. 36–45, Feb. 2005.

[3] S. Moon, L. Corradini, and D. Maksimovic, "Autotuning of digitallycontrolled boost power factor correction rectifiers," *IEEE Trans. PowerElectron.*, vol. 26, no. 10, pp. 3006–3018, Oct. 2011.

[4] A. El Aroudi, M. Orabi, R. Haroun, and L. Martinez-Salamero, "Asymptoticslow-scale stability boundary of PFC AC–DC power converters:Theoretical prediction and experimental validation," *IEEE Trans. Ind.Electron.*, vol. 58, no. 8, pp. 3448–3460, Aug. 2011.

[5] M. Chen and J. Sun, "Feedforward current control of boost single-phasePFC converters," *IEEE Trans. Power Electron.*, vol. 21, no. 2, pp. 338–345, Mar. 2006.

[6] H. C. Chen, H. Y. Li, and R. S. Yang, "Phase feedforward controlfor single-phase PFC boost-type SMR," *IEEE Trans. Power Electron.*,vol. 24, no. 5, pp. 1428–1432, May 2009.

[7] H. C. Chang and C. M. Liaw, "An integrated driving/charging switchedreluctance motor drive using three-phase power module," *IEEE Trans. Ind. Electron.*, vol. 58, no. 5, pp. 1763–1775, May 2011.

[8] J. Y. Chai, Y. H. Ho, Y. C. Chang, and C. M. Liaw, "On acoustic-noisereductioncontrol using random switching technique for switch-moderectifiers in PMSM drive," *IEEE Trans. Ind. Electron.*, vol. 55, no. 3,pp. 1295–1309, Mar. 2008.

Authors Details:

RESHMA

She received B.Tech degree from Ganapathy College of Engineering Rangashaipet(v), Warangal (m), Warangal dist.,Telangana in 2013. And currently pursuing M.Tech in power electronics at SSJ Engineering college, vattinagulapally, Gandipet, Hyderabad, Telangana. Her area of interest are in power electronics and drives, power systems .

CH VINAY KUMAR

Obtained his B.TECH (EEE) degree from ST.MARTINS ENGG COLLEGE, HYD., M.Tech.(Power Electronics) from JNTU Hyderabad. Currently he is working as Assoc. Prof. in SSJ Engineering college, Hyderabad. His areas of interest include Power Electronics & Drives, Power systems and Facts. He is having 8 years of teaching experience