Analysis of Multilevel Inverter topology with a reversing-voltage Concept

N DEVIPRIYA [#1],Mr. G MadhuSagarBabu [*2]

[1]*EEE department, SCET(JNTUK), Narsapur, A.P India.*
[2]*EEE department, Sri Vasavi Engineering College (JNTUK), Tadepalligudem,A.P India.*
[1]devipriya.nallamilli@gmail.com
[2]gm.sagarbec@gmail.com

Abstract— **Multi level inverter is used in applications that need high voltage and high current. The topologies of multilevel inverter have several advantages such as lower THD, lower EMI generation, better output waveform and higher efficiency for a given quality of output waveform. The main feature of multilevel inverter is the ability to reduce the voltage stress on each power device due to the utilization of multilevel on the DC bus. However, it has some disadvantages such as increased number of components, complex pulse width modulation control method, and voltage-balancing problem.**
In this paper, a topology with a reversing-voltage component is proposed to improve the multilevel performance by compensating the disadvantages mentioned. This topology compared to existing inverters requires fewer components (particularly in higher levels) and requires fewer carrier signals and gate drives. Therefore, the overall cost and complexity are greatly reduced particularly for higher output voltage levels. Finally, the paper includes simulation results of RVMLI fed Single phase Induction Motor using In-phase Disposition (IPD) PWM technique.

Keywords— **Multi Level Inverters, RVMLI, THD, IPD PWM.**

I. INTRODUCTION

A multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy. In recent years, there has been a substantial increase in interest to multilevel power conversion. The term multilevel began with the three-level converter. The advantages of three-level Inverter topology over conventional two-level topology are:

1. The voltage across the switches is only one half of the DC source voltage;
2. The switching frequency can be reduced for the same switching losses;
3. The higher output current harmonics are reduced by the same switching frequency.

Recent research has involved the introduction of novel converter topologies and unique modulation strategies. However, the most recently use d inverter topologies, which are mainly addressed as applicable multilevel inverters, are cascade converter, neutral-point clamped(NPC) inverter, and flying capacitor inverter. There are also some combinations of the mentioned topologies as series combination of a two-level converter with a three-level NPC converter which is named cascade 3/2 multilevel inverter [3]. There is also a series combination of a three-level cascade converter with a five-level NPC converter which is named cascade 5/3 multilevel inverter [4]. The proposed topology is a symmetrical topology since all the values of all voltage sources are equal. However, there are asymmetrical topologies [5] which require different voltage sources. This criterion needs to arrange dc power supplies according to a specific relation between the supplies. Difference in ratings of the switches in the topology is also a major drawback of the topology. This problem also happens in similar topologies [6]–[8], while some of the high-frequency switches should approximately withstand the maximum overall voltage which makes its application limited for high-voltage products.

In practical implementation, reducing the number of switches and gate driver circuits is very important. RV (Reverse Voltage) multilevel inverter will obtain a nearly sinusoidal voltage with a lower switch count [1]. Single phase AC supply obtained from this topology is given to single phase Induction Motor and are the most common domestic appliance due to their rugged construction and lower cost. Also this topology can be easily implemented for three phase system due to less number of switches and hence less complexity of controlling them.

II. CIRCUIT TOPOLOGY

The power circuit of the inverter consists of the power semiconductor switches which are combined to produce a high-frequency waveform in positive and negative polarities. However, there is no need to utilize all the switches for generating bipolar levels. This idea has been put into practice by the new topology [1].This topology is a hybrid multilevel topology which separates the output voltage into two parts. One part is named *level generation* part and is responsible for level generating in positive polarity. This part requires high-frequency switches to generate the required levels. The switches in this part should have high-switching-frequency capability. The other part is called *polarity generation* part and is responsible for generating the polarity of the output voltage, which is the low-frequency part operating at line frequency. The topology combines the two parts (high frequency and low frequency) to generate the multilevel voltage output. In order to generate a complete multilevel output, the positive levels are generated by the high-frequency part (level generation), and then, this part is fed to a full-bridge inverter (polarity generation), which will generate the required polarity for the output. This will eliminate many of the semiconductor switches which were responsible to generate the output voltage levels in positive and negative polarities.

The RV topology in seven levels is shown in Fig. 1. As can be seen, it requires ten switches and three isolated sources. The principal idea of this topology as a multilevel inverter is that the left stage in Fig. 1 generates the required output levels (without polarity) and the right circuit (full-bridge converter) decides about the polarity of the output voltage. This part, which is named polarity generation, transfers the required output level to the output with the same direction or opposite direction according to the required output polarity. It reverses the voltage direction when the voltage polarity requires to be changed for negative polarity.

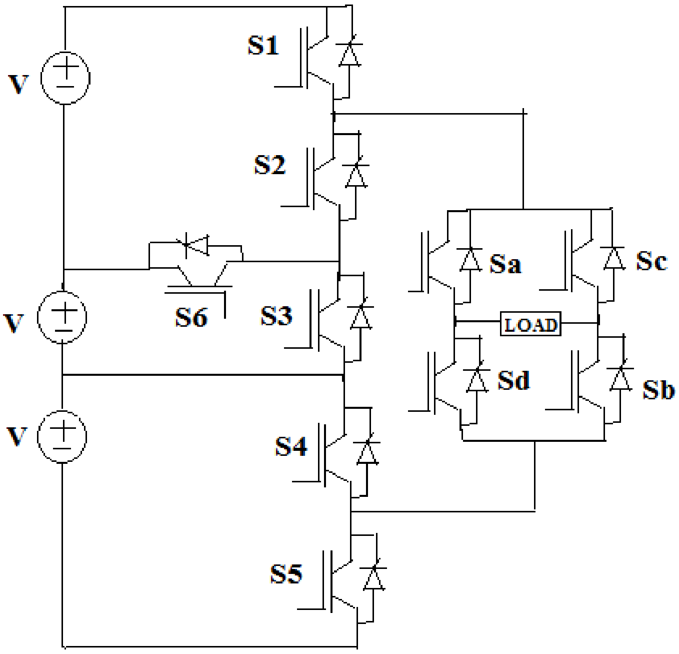

Fig.1 Seven level structure of RVMLI.

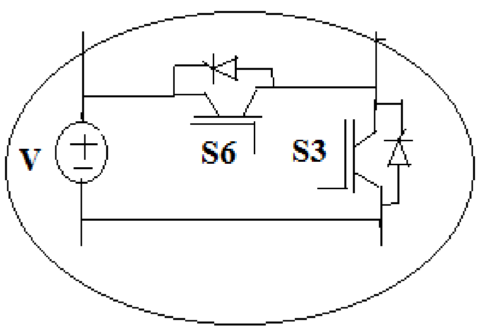

Fig.2 RVMLI duplicate stage for higher levels

This topology easily extends to higher voltage levels by duplicating the middle stage as shown in Fig. 1. Therefore, this topology is modular and can be easily increased to higher voltage levels by adding the middle stage in Fig. 2. Hence the higher levels are obtained easily and with fewer components.

Switching sequences in this converter are easier than its counter parts. According to its inherent advantages, it does not need to generate negative pulses for negative cycle control. Thus, there is no need for extra conditions for controlling the negative voltage. Instead, the reversing full-bridge converter performs this task, and the required level is produced by the high-switching-frequency component of the inverter. Then, this level is translated to negative or positive according to output voltage requirements. This topology is redundant and flexible in the switching sequence. In this paper, IPD SPWM is adopted for its simplicity. Carriers in this method do not have any coincidence, and they have definite offset from each other. They are also in phase with each other. The modulator and three carriers for SPWM are shown in below Fig.

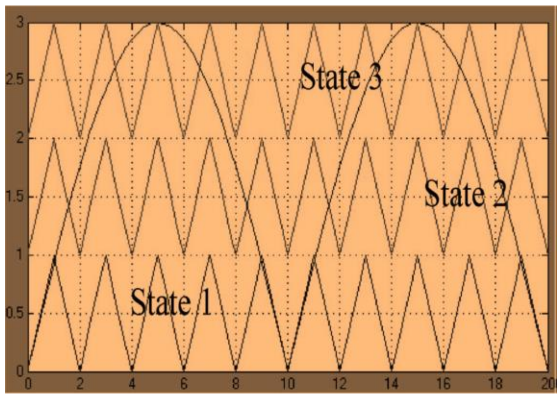

Fig.3 IPD PWM structure of RVMLI

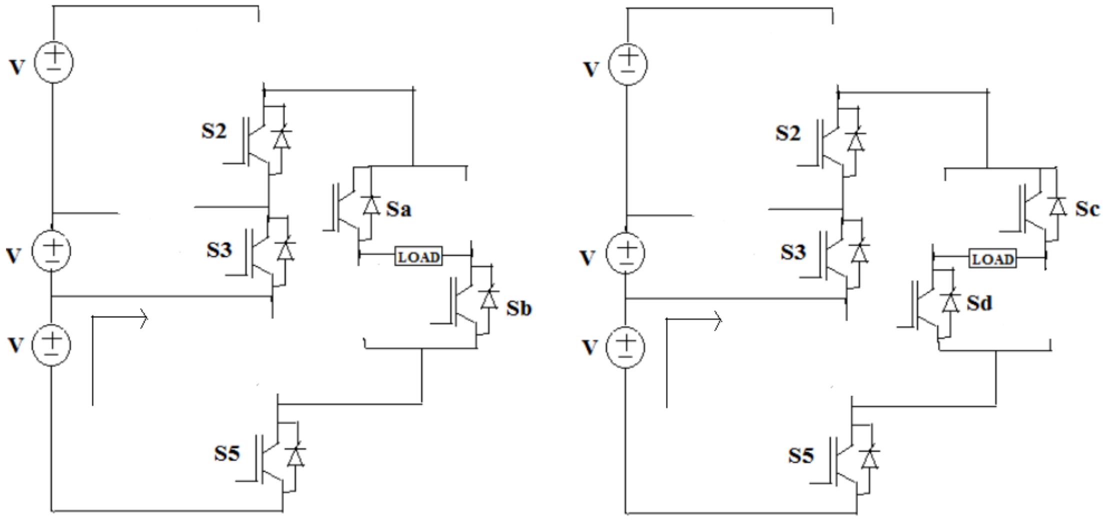

Fig.4 RVMLI operating mode-level 1(±116 V).

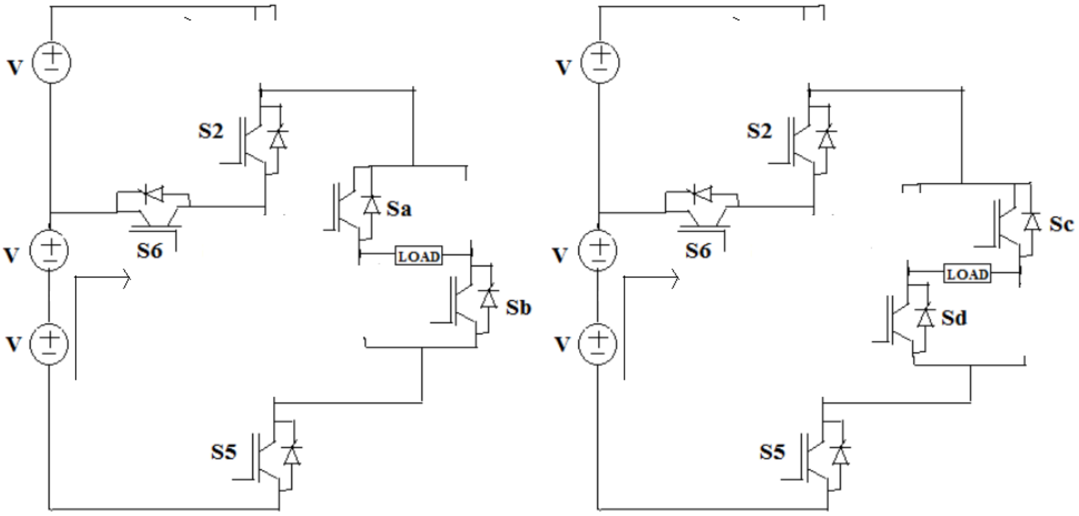

Fig.5 RVMLI operating mode-level 2(±232 V).

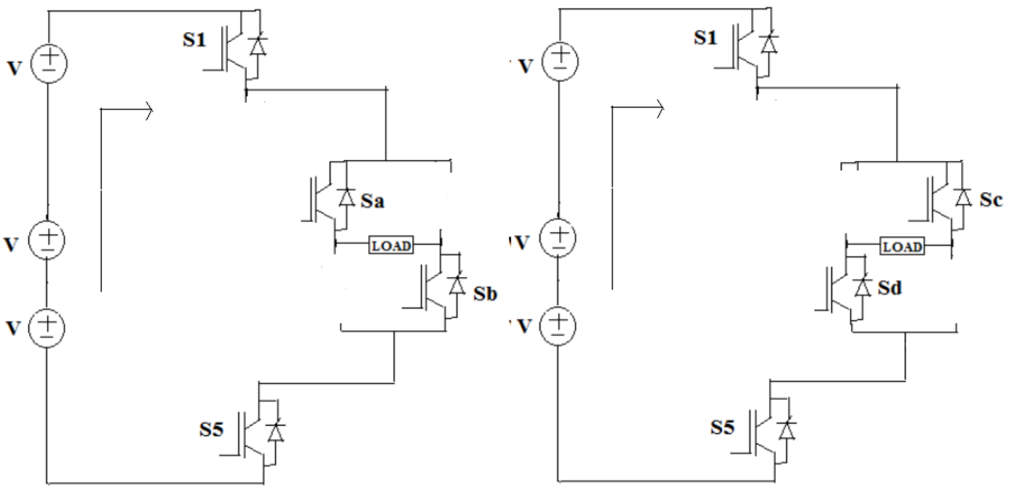

Fig.6 RVMLI operating mode-level 3(±350 V).

III. SIMULATION RESULTS

The RVMLI has been implemented and simulated using MATLAB for Resistance& Induction motors as loads. The THD of 3.55% for seven level topology with filter has been obtained and shown in fig.11 and the results of RVMLI topology with Induction Motor load are shown in figures (8, 9, 10, 12, 13& 14).

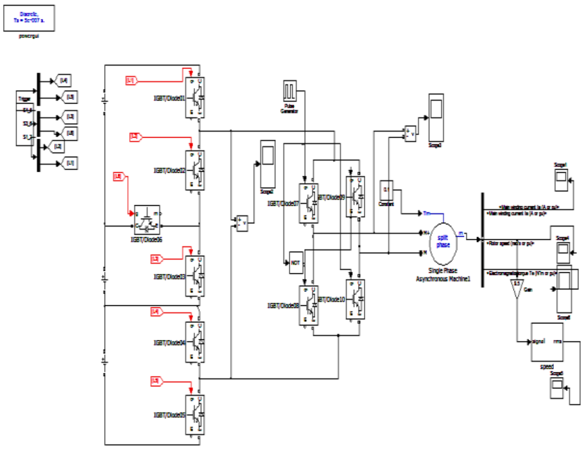

Fig.7 Simulation Circuit for RVMLI fed single-phase Induction Motor.

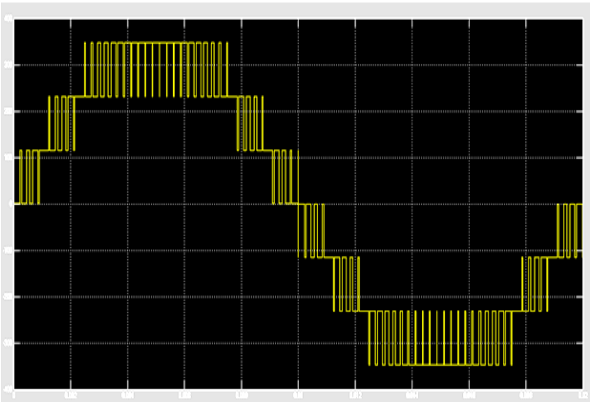

Fig.8 output voltage waveform of RVMLI with R-load without filter

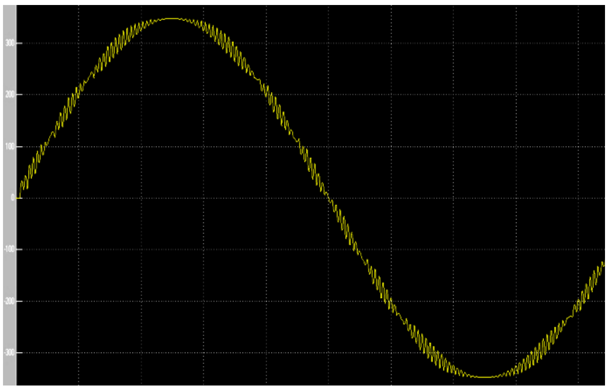

Fig.9 output voltage waveform of RVMLI with R-load with filter

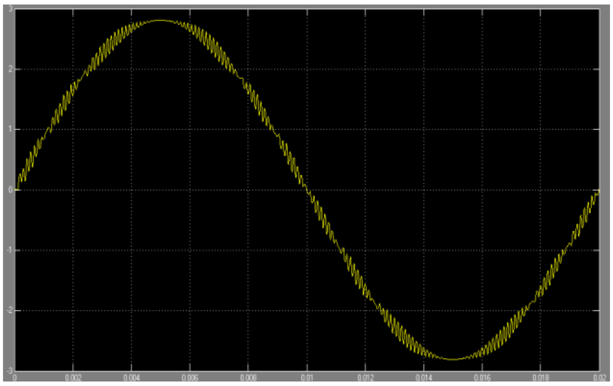

Fig.10 output current waveform of RVMLI with R-load with filter

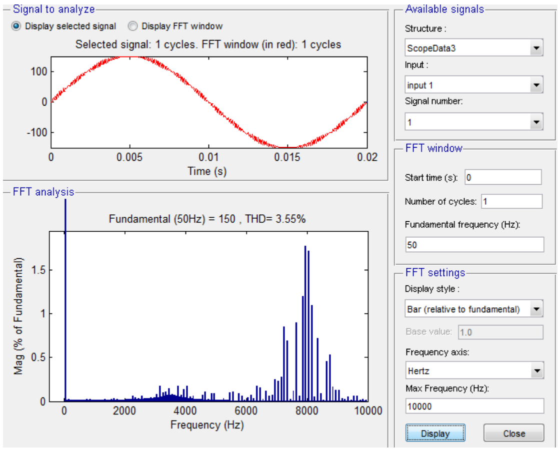

Fig. 11 FFT Analysis

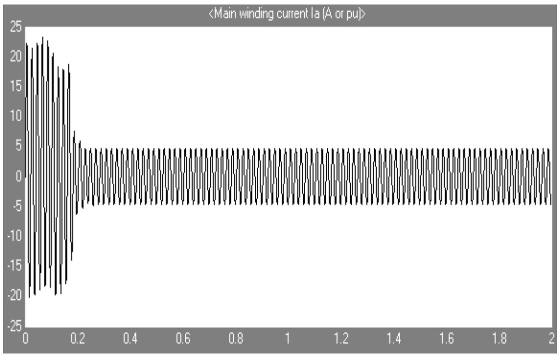

Fig.12 Stator current waveform of RVMLI fed single phase induction motor.

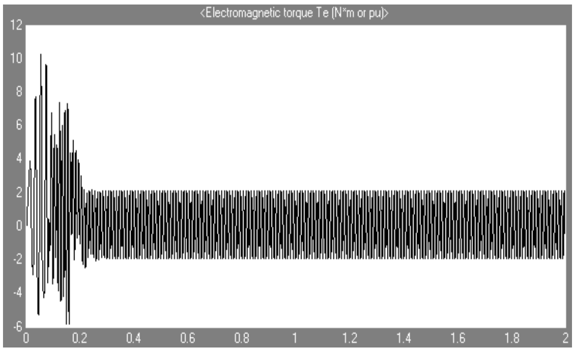

Fig.13 Torque waveform of RVMLI fed single phase induction motor.

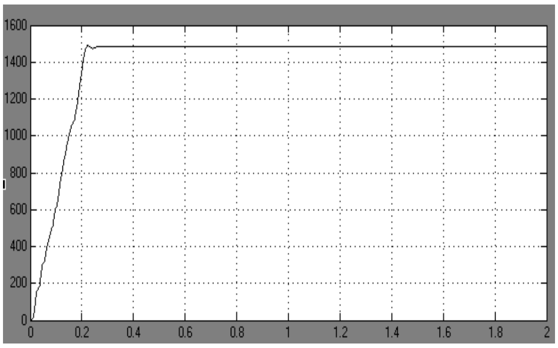

Fig.14 speed waveform of RVMLI fed single phase induction motor.

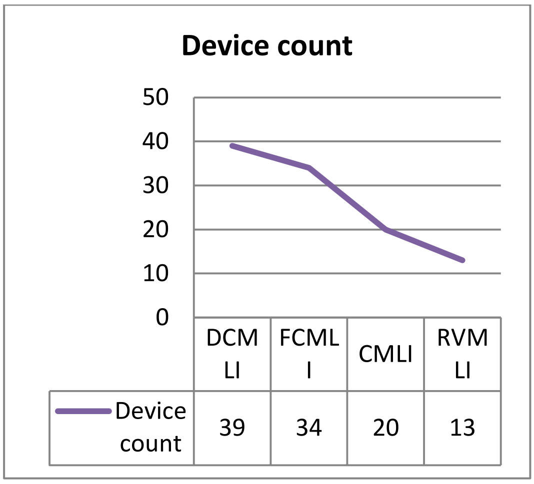

Fig.15 Comparison of device count between various multilevel structures.

IV. CONCLUSION

In RV (Reverse Voltage) multilevel inverter topology, the switching operation is separated into high- and low-frequency parts. This will add up to the efficiency of the converter as well as reducing the size and cost. This topology can be a good candidate for converters used in power applications such as FACTS, HVDC, PV systems, UPS, etc

A RVMLI topology provides the better sinusoidal output voltage with low THD and also requirement of gate drivers, protection circuits, installation area and converter cost is reduced compared with existing MLI topologies. In this paper, with this topology, single phase Induction Motor is driven and simulation results are obtained.

REFERENCES

[1] Ehsan Najafi, *Member, IEEE*, and Abdul Halim Mohamed Yatim, *Senior Member, IEEE"Design and Implementation of a New Multilevel Inverter Topology"* IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 59, NO. 11, NOVEMBER 2012

[2] Chiasson J.; Tolbert L.; McKenzie K.; Du Z.: Real-time Computer Control of a Multilevel Converter using the Mathematical Theory of Resultants. Elsevier J. Math. Comput.Simul, Nov. 2003, vol. 63 (3-5), pp. 197-208.

[3] T. L. Skvarenina, *The Power Electronics Handbook*. Boca Raton, FL:CRC Press, 2002.

[4] X. Yun, Y. Zou, X. Liu, and Y.He, "A novel composite cascade multilevel converter," in *Proc. 33rd IEEE IECON*, 2007, pp. 1799–1804.

[5] E. Beser, B. Arifoglu, S. Camur, and E. K. Beser, "Design and application of a single phase multilevel inverter suitable for using as a voltage harmonic source," *J. Power Electron.*, vol. 10, no. 2, pp. 138–145,Mar. 2010.

[6] G. Ceglia, V. Guzman, C. Sanchez, F. Ibanez, J. Walter, and M. I. Gimenez, "A new simplified multilevel inverter topology for dc-ac conversion," *IEEE Trans. Power Electron.*, vol. 21, no. 5, pp. 1311–1319,Sep. 2006.

[7] N. A. Rahim, K. Chaniago, and J. Selvaraj, "Single-phase seven-level grid-connected inverter for photovoltaic system," *IEEE Trans. Ind. Electron.*,vol. 58, no. 6, pp. 2435–2443, Jun. 2011.

[8] J. Selvaraj and N. A. Rahim, "Multilevel inverter for grid-connected PV system employing digital PI controller," *IEEE Trans. Ind. Electron.*,vol. 56, no. 1, pp. 149–158, Jan. 2009.

[9] Carpita M, Marchesoni M, Pellerin M, Moser D. Multilevel converter for traction applications: small-scale prototype tests results. IEEE Trans Ind Electron 2008

[10] Carpita M, Marchesoni M, Pellerin M, Moser D. Multilevel converter for traction applications: small-scale prototype tests results. IEEE Trans Ind Electron 2008

[11] Shuai Lu, Corzine KA. Advanced control and analysis of cascaded multilevel converters based on P-Q compensation. IEEE Trans Ind Electron 2007

[12] Gui-Jia Su. Multilevel dc-link inverter .IEEE Trans Indus Appl 2005.

[13]G. Shahgholiyan, E. Haghjou, and S. Abazari, "Improving the mitigation of voltage flicker by usage of fuzzy control in a distribution static synchronous compensator (DSTATCOM)," *Majlesi J. Elect. Eng.*, vol. 3, no. 2,pp. 25–35, Jun. 2009.

