Voltage Gain Enhancement in PV Fed Interleaved Boost Converter using Voltage Multiplier Module

R.Roja[1] V.Suvitha[2]
[1]P.G. Scholar [2]Assistant Professor
[1,2]Department of Electrical and Electronics Engineering
[1,2]Prathyusha Institute of Technology and Management, Thiruvallur-602205

Abstract— The main objective of the project is to design and implement a high gain step up converter using voltage multiplier module for photovoltaic system. The High step up converter obtains high step up gain without operating at extreme duty ratio. Also, voltage multiplier module which is composed of coupled inductor and switched capacitor. The coupled inductor can be designed to extend high step up gain and the switched capacitor are used to achieve a higher voltage conversion ratio. The Bidirectional inverter which acting as both rectification, inversion mode was implemented to maintain the Dc grid voltage.

Key words: High step up converter, voltage multiplier module, Bidirectional Inverter, PV system

I. INTRODUCTION

Renewable energy source also called non-conventional type of energy are the sources which are continuously replenished by natural processes. Such as, Solar energy, Bio energy, Wind energy and Hydro power etc. Among renewable energy systems, photovoltaic systems are expected to play an important role in future energy production. Fuel cell is one of the promising energy technologies for the sustainable future with its high energy efficiency and environment friendly nature when the world is facing the global warming problem. Photovoltaic sources are used today in many applications such as battery charging, water pumping, home power supply, swimming-pool heating systems, satellite power systems etc. They have the advantage of being less maintenance and no pollution. Such systems transform light energy into electrical energy and convert low voltage into high voltage through high step up converter, which can convert energy into electricity using a grid by grid inverter or dc micro grid. For low input voltage from PV panel cannot make higher efficiency at PV inverter. Several converter topologies are proposed to increase PV output voltage as we required. The single phase boost converters are provide more input current ripple, which in turn increases the conduction loss of the switch. To minimize the current stress, voltage stress and input current ripple interleaved technique is used. The combination of coupled inductor and switched capacitor is a better concept. Moreover, high step up gain, high efficiency and low voltage stress are achieved even for high power applications. The bidirectional inverter to perform both grid connection and rectification mode was to maintain the dc bus voltage for dc distribution. During this inversion mode, Bidirectional inverter gets the high voltage from High step up converter through the dc grid and which converts dc voltage into ac voltage from High step up converter through the dc grid and which convert dc voltage into ac voltage given to the ac load. During rectification mode, Bidirectional inverter performs as a rectifier and which get the voltage from ac source and the rectifier converts ac voltage into dc voltage stored into the dc grid.

II. PROPOSED SYSTEM

In this proposed system have three main parts such as PV module, high step up converter and bidirectional inverter. Thus the high converter is the important stage in the system because such a system requires a high step up conversion and high efficiency.

The high step up converter connected from the PV supply to dc grid. PV system transform light energy into electrical energy and convert low voltage into high voltage through a high step up converter which can converts energy into electricity using a grid by grid inverter. But the conventional step up converter such as the boost converter and flyback converter cannot achieve a high step conversion with high efficiency because of the resistance of elements.

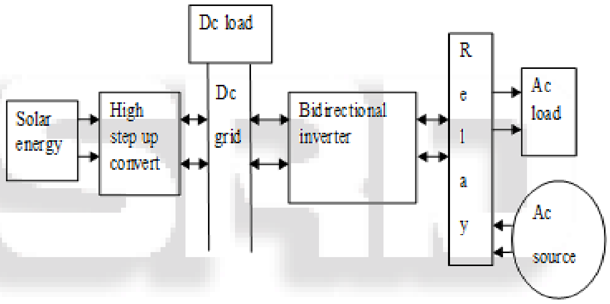

Fig. 1: Proposed System Block Diagram.

After the dc load gets the high amount of voltage from the high step up converter. Finally Bidirectional inverter converts dc voltage into ac voltage given to the ac load.

If there is no energy gets from the PV module due to the weather condition, the bidirectional inverter act as a rectifier which gets the source from ac source and the rectifier which converts ac voltage into dc voltage and to maintain the Dc grid voltage.

III. ANALYSIS OF HIGH STEP UP CONVERTER

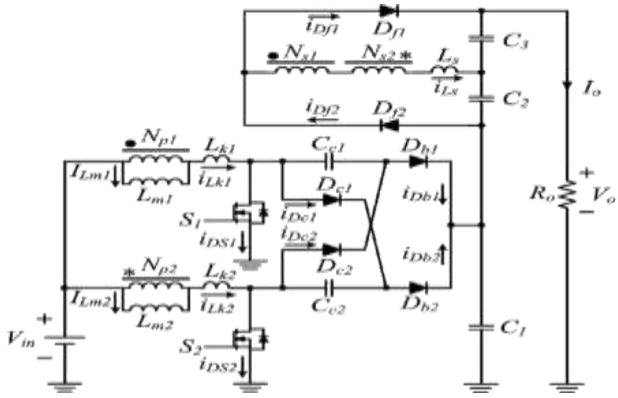

Fig. 2: Circuit Diagram of Proposed Converter

All rights reserved by *www.ijsrd.com*

The proposed high step up converter consists of interleaved boost converter with voltage multiplier module, and the voltage multiplier module composed of coupled inductor and switched capacitor. Using this topology voltage ripple and conduction losses across the switches get reduced. The voltage gain of the proposed high step converter is increased by using coupled inductor and the switched capacitors are used to achieve a higher voltage conversion ratio. Input side of converter has primary of coupled inductor and secondary of coupled inductor connected to the voltage multiplier cell. The proposed high step up converter shown in fig 2.The high step up converter consist of main switch S_1,S_2 ; Magnetizing inductor L_{m1},L_{m2} ; Output capacitor C_1,C_2,C_3 ; Clamping diodes Dc1,Dc2 ; Output diodes D_{b1},D_{b2} ; Switched capacitor C_{c1},C_{c2} ; Output capacitor C_1,C_2,C_3; Leakage inductor Lk1,Lk2.The proposed converter operating in continuous conduction mode and the operation of high step up converter has five modes of operation.

A. *Mode 1:*

In mode1 switch S_1, S_2 both are turned ON position, all of the diodes are reverse biased. Current L_{k1}, L_{k2} increased linearly. During this period energy stored in the magnetizing inductor L_{m1} , L_{m2} as well as leakage inductor L_{k1},L_{k2}.

B. *Mode 2:*

In mode 2 Switch S_2 is OFF state , thereby turning ON D_{c2},D_{b2},D_{f1}.The energy that magnetizing inductor L_{m2} has stored is transferred to the secondary side charging the output capacitor C_3. The input voltage source L_{m2},L_{k2}, C_{c2} release the energy to the output capacitor C_1 through diode D_{b2} there by voltage across C_1 can obtain double output voltage of the boost converter.

Voltage on clamp capacitor Cc is derived from boost converter is given below

$$V_{Cc} = \frac{1}{1-D} V_{in}$$

When one of the switches turns off, voltage *VC*1 can obtain a double output voltage of the boost converter

$$V_{C1} = \frac{1}{1-D} V_{in} + V_{Cc}$$

$$V_{C1} = \frac{1}{1-D} V_{in} + \frac{1}{1-D} V_{in}$$

$$V_{C1} = \frac{2}{1-D} V_{in}$$

C. *Mode 3:*

Diode D_{b2} automatically get switched off because the total energy of leakage inductor L_{k2} has been completely released to the output capacitor C_1. L_{m2} still transfer the energy to the secondary side charging the capacitor C_3

D. *Mode 4:*

Mode 4 similar to that of Mode 1

E. *Mode 5:*

In Mode 5 switch S_1 is OFF state there by turn on D_{c1}, D_{b1}, D_{f2}. The energy stored in magnetizing inductor L_{m1} is transferred to the secondary side charging the output capacitor C_2 and the series leakage inductor flows to the output capacitor through the D_{f2}. Input voltage source L_{m1}, C_{c1}, L_{k1} release the energy to the output capacitor C_1 there by voltage across V_{c1} can obtain double output voltage of the boost converter

When switch S_2 ON state, S_1 is OFF state and S_1 ON state, S_2 OFF state; Thus voltage across C_2, C_3 can be derived from

$$V_{C2} = V_{C3} = n.\ V_{in}(1 + \frac{D}{1-D}) = \frac{n}{1-D} V_{in}$$

The output voltage is some of voltage across C_1, C_2, and C_3 can be derived as below

$$V_0 = V_{C1} + V_{C2} + V_{C3}$$

$$V_0 = \frac{2n+2}{1-D} V_{in}$$

Voltage gain of the proposed converter

$$V_0 / V_{in} = \frac{2n+2}{1-D}$$

IV. SIMULATION RESULTS OF PROPOSED CONVERTER

Fig 3 shows the PV with High step up converter. This is the simulink circuit diagram of proposed converter.

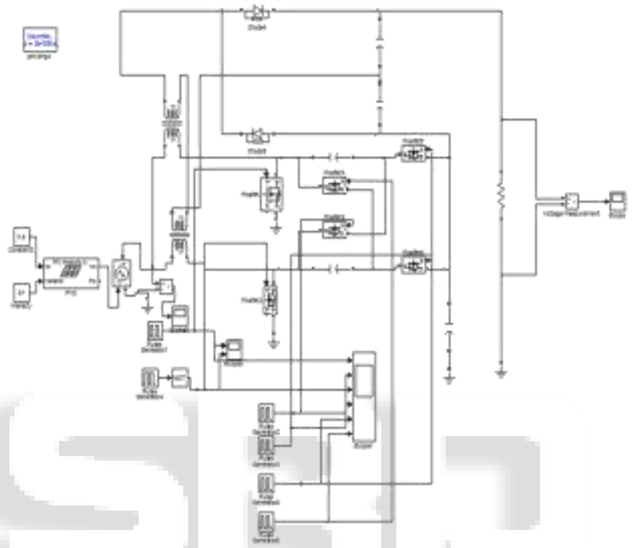

Fig. 3: Simulink diagram of High step up converter

This system having the advantage of step up high voltage over the normal Boost Converter because this proposed converter has integrated with voltage multiplier module and the voltage multiplier module composed of couple inductor and switched capacitor. Here include output voltage and output voltage ripple of high step up converter. Here include the output voltage and output voltage ripple of High step up converter using voltage multiplier module.

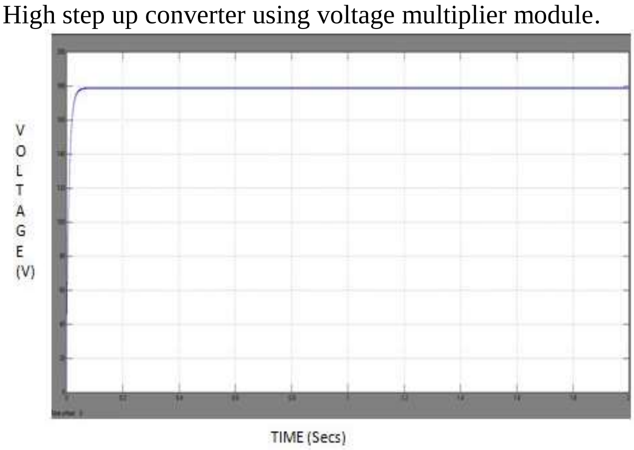

Fig. 4: Output voltage of High step converter using voltage multiplier module.

Fig4 Shows the output voltage of high step up converter using voltage multiplier module and the output voltage is 180V.

All rights reserved by *www.ijsrd.com*

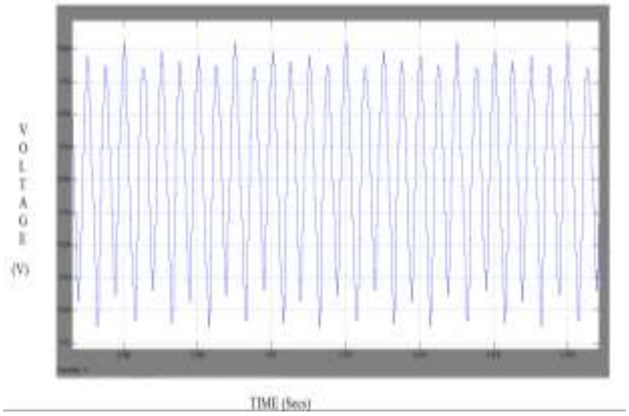

Fig: 5 Output voltage ripple of High step up converter

Fig 5 shows the output voltage ripple waveform of high step interleaved converter with voltage multiplier module and the ripple voltage was found to be 0.4V.

Topology	Input voltage	Output voltage	Output voltage Ripple	Gain
High step up converter	12V	180V	0.4V	15

Table 1: Proposed converter topology

V. Simulation Results of Open Loop System

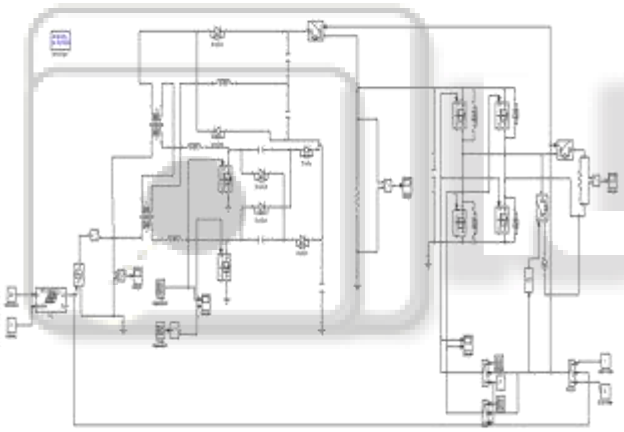

Fig. 6: Simulink diagram of open loop system

Fig 6 shows the simulink diagram of open loop system. Here the input voltage of High steps up converter getting from the PV module 12V. This proposed converter converts it to 180V to the Dc load side and the Bidirectional inverter which converts Dc voltage into Ac voltage to the Ac load side**.** Simulation result of Dc load voltage, Ac load voltage as given as below.

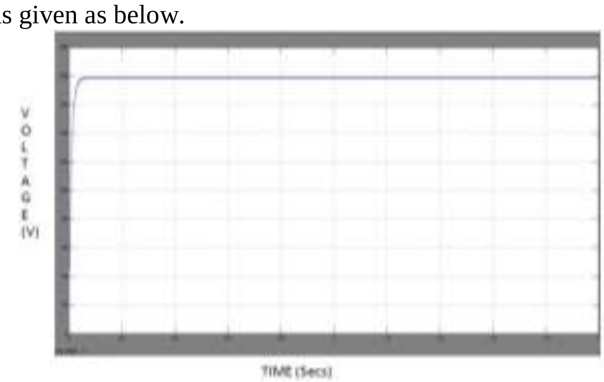

Fig. 7: Output voltage of High step up converter

Fig 7 shows the output voltage of High step up converter and the output voltage is180V.

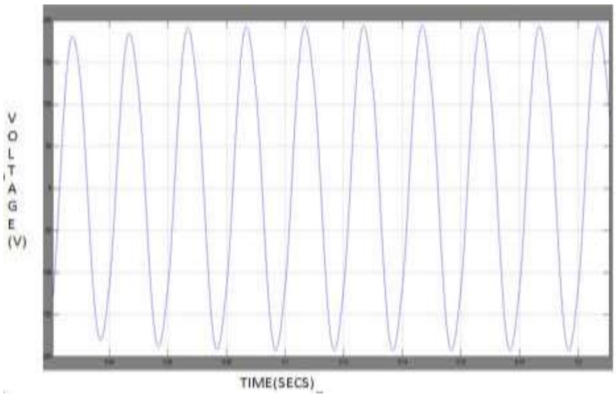

Fig. 8: Output voltage of inverter during inversion mode

Fig 8 shows the output voltage of inverter during inversion mode of operation. During the rectification mode of operation, Bidirectional inverter act as a rectifier converts Ac voltage into Dc from the Ac source.

VI. Simulation Results of Closed Loop System

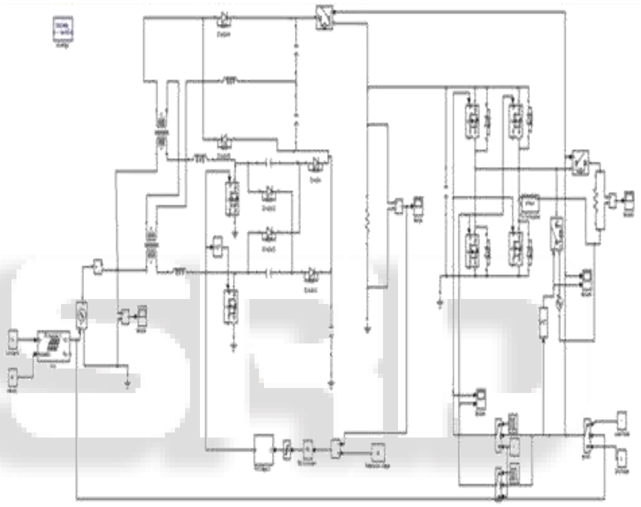

Fig. 9: Simulink diagram of closed loop system

In a closed-loop system, a controller is used to compare the output of a system with the required condition and convert the error into a control action designed to reduce the error and bring the output of the system back to the desired response.

Fig 9 shows the simulation diagram of closed loop system with PI controller. The PI controller output is proportional to the error signal, which is the difference between the set point and measured variable. The Proportional-Integral (PI) algorithm computes and transmits a controller output (CO) signal every sample time T, to the final control element.

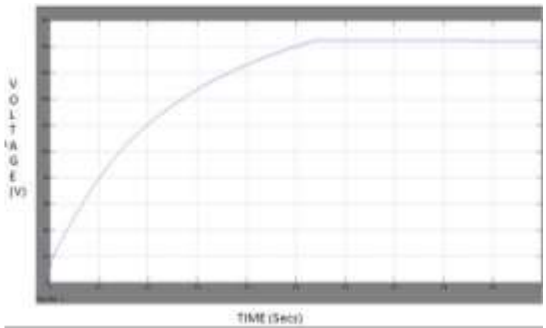

Fig. 10: Output voltage of High step up converter

All rights reserved by *www.ijsrd.com*

Fig 10 shows the output voltage of High step up converter and the output voltage are 180.

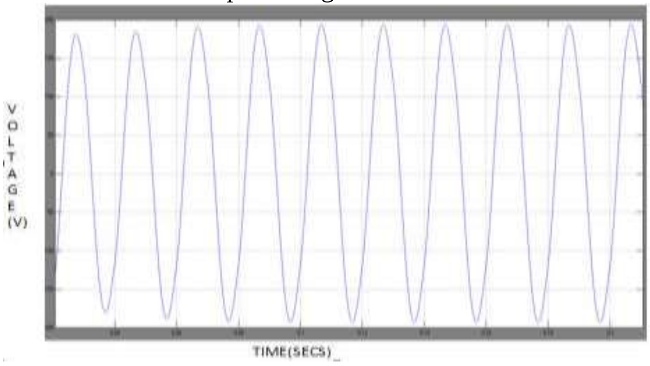

Fig. 11: Output voltage of inverter during inversion mode

Fig 11 shows the output voltage of inverter during inversion mode. During the rectification mode, Bidirectional inverter which acts as a rectifier converts ac into dc from the Ac source.

VII. CONCLUSION

This project describe the simulation of the High step up through the voltage multiplier module for PV application was successfully carried out using Matlab simulink software and the output waveforms were obtained. Then they obtained output responses of the High step up converter and Bidirectional inverter was analyzed. The proposed High step up converter through the voltage multiplier module and the voltage multiplier module composed of coupled inductor and switched capacitor. The coupled inductors can be designed to extend high step up gain and the switched capacitors offers extra voltage conversion ratio. The next factor in this proposed system is Bidirectional inverter which acting as both rectification, inversion mode to maintain the dc grid voltage. During this inversion mode, Bidirectional inverter gets the high voltage from High step up converter through the dc grid and which converts dc voltage into ac voltage given to the ac load. During this rectification mode, Bidirectional inverter perform as a rectifier and which gets the voltage from ac source, and the rectifier converts ac voltage converted into dc voltage stored into the dc grid.

REFERENCES

[1] A. I. Bratcu, I. Munteanu, S. Bacha, D. Picault, and B. Raison, "Cascaded DC–DC converter photovoltaic systems: Power optimization issues,"IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 403–411, Feb. 2011.
[2] R. J. Wai and W. H. Wang, "Grid-connected photovoltaic generation system," IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 55, no. 3, pp. 953–964, Apr. 2008.
[3] B. Yang, W. Li, Y. Zhao, and X. He, "Design and analysis of a grid connected photovoltaic power system," IEEE Trans. Power Electron.,vol. 25, no. 4, pp. 992–1000, Apr. 2010.
[4] W. Li and X. He, "Review of non-isolated high-step-up DC/DC converters in photovoltaic grid-connected applications," IEEE Trans. Ind. Electron.,vol. 58, no. 4, pp. 1239–1250, Apr. 2011.
[5] C. T. Pan and C. M. Lai, "A high-efficiency high step-up converter with low switch voltage stress for fuel-cell system applications," IEEE Trans.Ind. Electron., vol. 57, no. 6, pp. 1998–2006, Jun. 2010.
[6] R. J.Wai and R. Y. Duan, "High step-up converter with coupled-inductor,"IEEE Trans. Power Electron., vol. 20, no. 5, pp. 1025–1035, Sep. 2005.
[7] Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, "Novel high step up DC–DC converter with coupled-inductor and switched-capacitor techniques for a sustainable energy system," IEEE Trans. Power Electron.,vol. 26, no. 12, pp. 3481–3490, Dec. 2011.
[8] Y.-P. Hsieh, J.-F. Chen, T.-J. Liang, and L. S. Yang, "A novel high step-up DC–DC converter for a microgrid system," IEEE Trans. Power Electron.,vol. 26, no. 4, pp. 1127–1136, Apr. 2011.
[9] J. T. Bialasiewicz, "Renewable energy systems with photovoltaic power generators: Operation and modeling," IEEE Trans. Ind. Electron., vol. 55,no. 7, pp. 2752–2758, Jul. 2008.
[10] T. J. Liang and K. C. Tseng, "Analysis of integrated boost–flyback step up converter," Proc. Inst. Elect. Eng.—Elect. Power Appl., vol. 152, no. 2,pp. 217–225, Mar. 2005.
[11] L. S. Yang, T. J. Liang, and J. F. Chen, "Transformerless DC–DC converters with high step-up voltage gain," IEEE Trans. Ind. Electron., vol. 56,no. 8, pp. 3144–3152, Aug. 2009.
[12] R. J. Wai, C. Y. Lin, R. Y. Duan, and Y. R. Chang, "High-efficiency DC–DC converter with high voltage gain and reduced switch stress," IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 354–364, Feb. 2007.
[13] Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, "Novel high step-up DC–DC converter for distributed generation system," IEEE Trans. Ind.Electron., vol. 60, no. 4, pp. 1473–1482, Apr. 2013.
[14] Y. Jang and M. M. Jovanovic, "Interleaved boost converter with intrinsic voltage-doubled characteristic for universal-line PFC front end," IEEE Trans. Power Electron., vol. 22, no. 4, pp. 1394–1401, Jul. 2007.
[15] R. Gules, "Voltage multiplier cells applied to non-isolated DC–DC converters," IEEE Trans. Power Electron., vol. 23, no. 2, pp. 871–887,Mar. 2008.
[16] W. Li and X. He, "An interleaved winding-coupled boost converter with passive lossless clamp circuits," IEEE Trans. Power Electron., vol. 22,no. 4, pp. 1499–1507, Jul. 2007.
[17] G. A. L. Henn, R. N. A. L. Silva, P. P. Praca, L. H. S. C. Barreto, and D. S. Oliveira, Jr., "Interleaved-boost converter with high voltage gain,"IEEE Trans. Power Electron., vol. 25, no. 11, pp. 2753–2761, Nov. 2010.
[18] C. M. Lai, C. T. Pan, and M. C. Cheng, "High-efficiency modular high step-up interleaved boost converter for DC-microgrid applications," IEEE Trans. Ind. Appl., vol. 48, no. 1, pp. 161–171, Jan./Feb. 2012.
[19] D. Wang, X. He, and J. Shi, "Design and analysis of an interleaved flyback–forward boost converter with the current auto-balance characteristic," IEEE Trans. Power Electron., vol. 25, no. 2, pp. 489–498, Feb. 2010.
[20] W. Li, Y. Zhao, Y. Deng, and X. He, "Interleaved converter with Svoltage multiplier cell for high step-up and high-efficiency conversion," IEEE Trans. Power Electron., vol. 25, no. 9, pp. 2397–2408, Sep. 2010.

All rights reserved by *www.ijsrd.com*