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A New Single Stage Multilevel Converter for Power Factor Correction

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Abstract:

A Single Phase Single Stage Power Factor Corrected (SSPFC) AC/DC converter that operates with a single controller to obtain regulated dc output voltage is presented in this paper. The proposed converter integrates the operation of a boost power factor correction converter and a three-level and five level DC/DC converter into one converter. Due to the cost of having two separate and independent converters, there has been considerable research on so-called single-stage converters. Converters that can simultaneously perform AC-DC and DC-DC conversion with only a single converter stage. Elimination of one of these stages reduces the cost, weight, size, complexity and increase the overall reliability of this converter. The focus of the topology is to reduce the DC bus voltage at light load without compromising with input power factor and voltage regulation. The concept behind this topology is direct power transfer scheme. The proposed converter is having an input power factor close to unity and better voltage regulation and THD will be reduce compared to the conventional ac-dc converter topologies. The output wave from shown in Matlab/Simulink.

Keywords:
Power factor correction, single stage converters, three level converters.

I.INTRODUCTION:

Power-electronic inverters are becoming popular for various industrial drives applications. In recent years also high-power and medium-voltage drive applications have been installed. To overcome the limited semiconductor voltage and current ratings, some kind of series and/or parallel connection will be necessary. Due to their ability to synthesize waveforms with a better harmonic spectrum and attain higher voltages, multi-level inverters are receiving increasing attention in the past few years. THE ac–dc power supplies with transformer isolation are typically implemented with some sort of input power factor correction (PFC) to comply with harmonic standards such as IEC 1000-3-2 [1]. There have been numerous publications about SSPFC converters, particularly for low-power ac–dc fly back and forward converters [1]. Research on the topic of higher power ac–dc single-stage full-bridge converters, however, has proved to be more challenging, and thus, there have been much fewer publications [2]. Several single-stage ac–dc full-bridge current fed converters have been proposed [3]; these converters have a boost inductor connected to the input of the full bridge circuit. Although they can achieve a near-unity input power factor, they lack an energy-storage capacitor across the primary-side dc bus, which can result in the appearance of high voltage overshoots and ringing across the dc bus. It also causes the output voltage to have a large low-frequency 120-Hz ripple that limits their applications.

In the Industries the performance of the electrical equipments should comply with the regulatory standards. In order to improve the input power factor, some sort of power factor correction (PFC) methods is to be employed.The passive PFC method employs inductors and capacitors to filter out low frequency current harmonics.Though the method is simple and efficient, the passive filter converters have large size, weight and cost particularly at low frequency. Another PFC method is to use the conventional two stage converters.

Two converter stages i.e., an ac-dc conversion stage and an isolated dc-dc conversion stage are used to convert the input ac mains voltage into an isolated and regulated dc voltage. The ac-dc conversion stage is a boost converter which shapes the input current into almost sinusoidal thus obtaining power factor correction. In the isolated dc-dc conversion stage, voltage regulation is done. However they need two separate converters along with their own controllers for the operation resulting in a more expensive and less efficient converter.

Thus in the industries the new trend is to use single stage power factor correction (SSPFC) converters where the two converter stages are integrated into one. i.e., they perform both power factor correction and regulation using a single converter.Power supplies connected to ac mains introduce harmonic currents in the utility. It is very well known that these harmonic currents cause several problems such as voltage distortion, heating, noise and reduce the capability of the line to provide energy. This fact and the need to comply with "standards" or "recommendations" have forced to use power factor correction in power supplies mainly in low power applications. However, this is probably the In the next section a review of the various SSPFC topologies is been carried out. The advantages and limitations of each topology will be reviewed. A new three level integrated converter which overcomes the drawbacks of the previous topologies is proposed and the operation and design of the converter are explained in the subsequent sections.

II. The Single Stage Power Factor Corrected Topologies:

One classification of the SSPFC circuits is based on the number of switches in the converter. The SSPFC circuits provide the features of the power factor pre-regulators in addition to those of dc-dc converters cascaded with it. The basic SSPFC circuit was introduced in early 1990s by Madigan et.al. This was achieved by integrating the boost input shaping converter with either a fly-back or a forward topology [4].

A. Single switch topologies:

Many single switch single stage converter topologies have been proposed [7-10]. A single stage ac-dc converter is proposed in [5] in which the dc voltage is less dependent on the operating conditions. But the voltage stress is more on the switch. Also it contains low frequency output voltage ripples. The various problems associated with single switch topologies are lower power factor at low line input, dead angle problem of input current high capacitor voltage stress and higher switch voltage.

Advantages:

•Simple configuration
•Lesser number of components used

Limitations:

•High voltage stress across the switches and the bus capacitor
•Presence of circulating currents
•Cannot be used for higher power levels

B. Two switch topologies:

Half bridge converters have also been integrated in SSPFC topologies either in symmetrical or asymmetrical modes of operation [11]. They are able to provide high input power factor. Still they suffer from high circulating currents, high dc bus voltages or discontinuous currents [12]. The topology proposed in [12] has an auxiliary circuit which is used to get a reduced capacitor voltage stress. Here the converter is operated in DCM, thus achieving high input power factor. But the current stress on the converter switches becomes high. Thus the conduction losses increase resulting in lower efficiency. Hence these converters cannot be used for higher power applications.

Advantages:

•They are able to provide high input power factor
Limitations:
•Presence of circulating currents
•Either high dc bus voltage or discontinuous output current
•Low efficiency at power levels above 200W.

C. Four switch topologies:

Full bridge circuits are used as converters for higher power levels. SSPFC full bridge converters are presented in converters, the current fed converters have d low frequency ripple at the output voltage overshoot and ringing across the dc bus. The voltage fed PWM converters are UN voltage which is highly dependent on operate the input power factor which is not as go converters. The single stage resonant converter many attractive properties such as zero Volta single stage PFC Circuits based. Among these drawbacks such as eland high voltage he problems related regulated dc bus ting conditions and old as current fed enters have age switching, high-power densities due to the frequency, low cost and high optimize their design since the control. Three-level dc/dc co has low voltage stress across from a high dc-bus voltage.

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The levels with reduced voltage strategy the advantages and li stage converter topologies can Table I. In order to overcome level integrated ac-dc converts operation at high switching efficiency. But it is difficult to hey employ variable frequency converters proposed so the switches while operated hey can operate at higher power less across the switches. Imitations of the various single be summarized as shown in these limitations, a new three tar is presented in this paper.

Advantages:

•Can be used for higher power levels
•Voltage stress across capacitor can be limited to lower values
Limitations:
•Current fed converters: presence of high voltage overshoot and ringing across the dc bus and the presence of low frequency ripple at the output voltage.
•Voltage fed converters: excessive dc voltage and the output current is discontinuous at some operating points.
•Resonant converters: difficult to optimize the design since they employ variable frequency control.

III. Three Level Integrated AC-DC Converter:

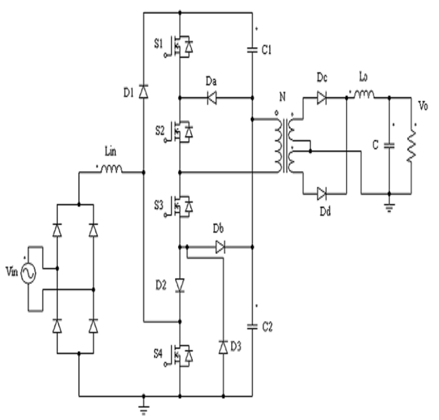

Fig.1 Proposed Three Level Single Stage Converters.

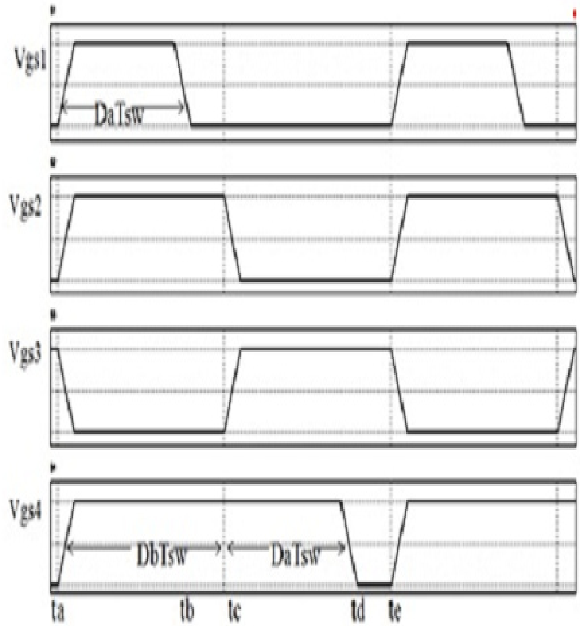

Fig.2 Switching Waveforms.

The proposed converter schematic is shown in Fig.1. It consists of a boost converter section and an isolated forward converter section. The boost section which performs the power factor correction consists of a front end full bridge diode rectifier, a boost inductor Lin, diode D1 and switch S4. Two bulk capacitors C1 and C2 are connected across the primary of the main transformer. When S4 is on, boost inductor is charging through S4 and VIN. When S4 is off, the energy stored in the boost inductor is flowing to the bus capacitors C1 and C2 through D1. Since D2 is reverse biased, input current does not flow to the midpoint of bus capacitors. When S4 is off, D3 provides a circulating path for the transformer primary current. The forward converter section consists of switches S1, S2, S3 andS4, main transformer, diodes

Dc and Dd and the output inductor Lo. Fig.2 shows the gating signals to the four switches of the converter. Referring to Fig. 2, from the instant ta to the switches S1 and S2 are on. The bus capacitor C1 discharges through switches S1 and S2 and the transformer primary winding and the energy is transferred to the load. Also the output inductor Lo charges through the transformer secondary winding and the load. At the same time since S4 is on, the boost inductor charges and the inductor current increases. At the instant tbS1 is turned off and the primary current circulates through diode Dad and switch S2. The transformer primary as well as secondary voltage is zero and now the output inductor Lo feeds the load.

The input inductor current keeps on increasing since S4 is on. Now at the instant tc S2 is turned off and S3 is turned on. The bus capacitor C2 discharges and energy is transferred to load through the output inductor. The input inductor current reaches its maximum at the instant tan the switch S4 is turned off. The primary current circulates through the path S3 and Db. The input inductor starts discharging its energy through the bus capacitors C1 and C2. Transformer secondary voltage is zero and the output inductor discharges through the load. Finally when S3 is also turned off (all switches off), the bus capacitor C1 is charged by the transformer primary to half the bus voltage through the body diodes of switches S1 and S2. The process repeats again.

IV. The Control Strategy of the Proposed Converter:

The basic block diagram of the new converter is shown in Fig. 3.The front end full bridge rectifier is fed with the AC mains. The rectified dc is given to the converter unit which consists of a boost section and an isolated forward converter section. The boost section shapes the input current into a more sinusoidal form thus providing natural power factor correction. Two bulk capacitors are connected at the primary side of the isolation transformer forming the dc link. There are two control units. Control unit1 regulates the output voltage to the desired value and control unit2 regulates the input power factor thereby regulating the dc bus voltage across the capacitors.

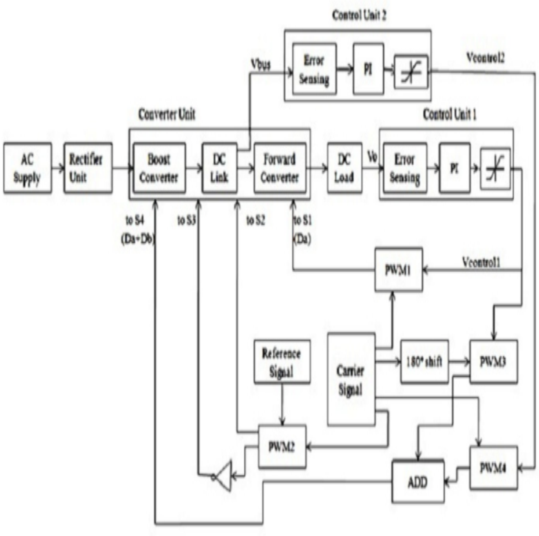

Fig. 3 Basic Block Diagram Of The Control Strategy Of The Proposed Converter.

The output voltage is given to the which consists of error sensing, PI controlled Blocks to produce the control voltage Vcon the dc bus voltage is given to the control unit control voltage Vcontrol2. The switching s PWM1 is generated by comparing Control signal having switching frequency same proposed converter. Switching signals for generated by comparing a reference signal. The pulses to these switches are 18 the switching signal for S4 is generated signal Vcontrol1 is compared with the c produce PWM3. The control signal Control with the carrier signal to generate PWM4.signals is added together and it is given to S4.

V.MATLAB/SIMULINK RESULTS:

Case I Single phase single stage power factor corrected converter for three level

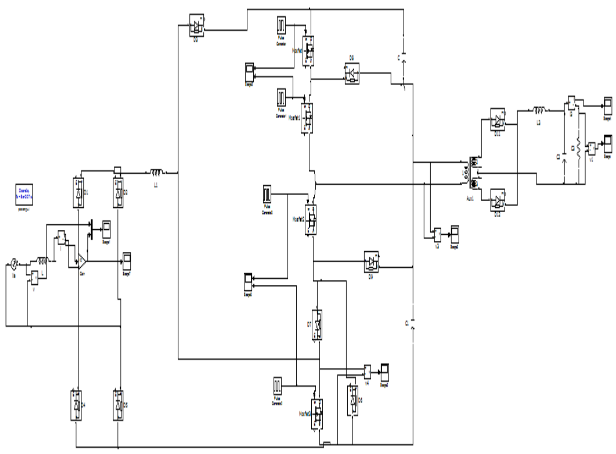

Fig.4. Simulink Circuit for Three Level

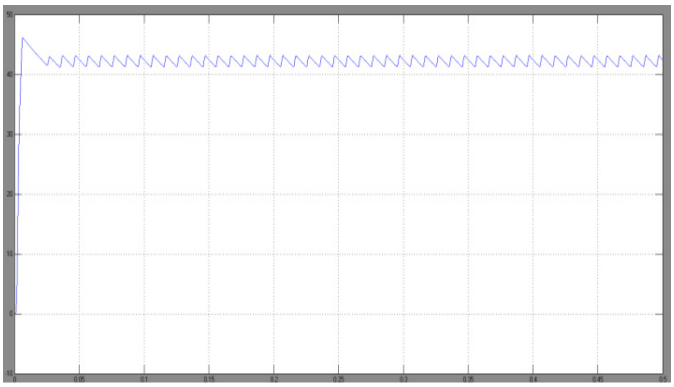

Fig.5. Output Voltage

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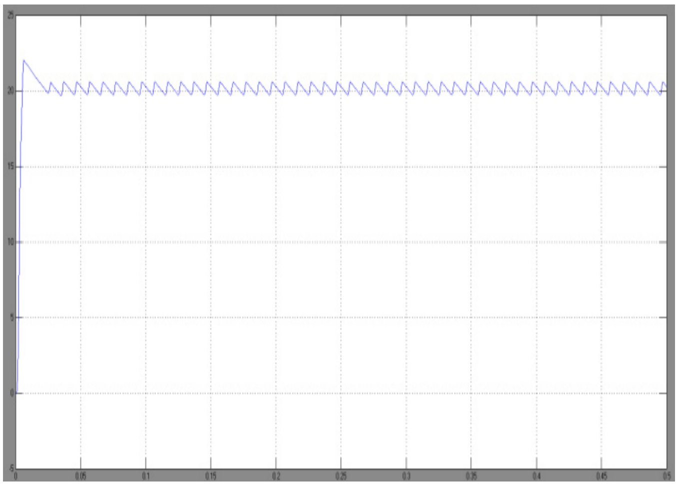

Fig.6. Output Current

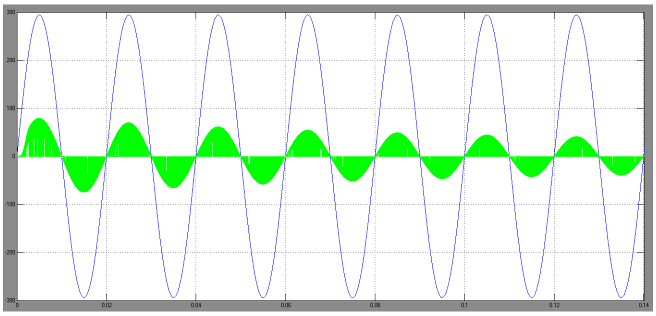

Fig.7. Input Voltage And Current

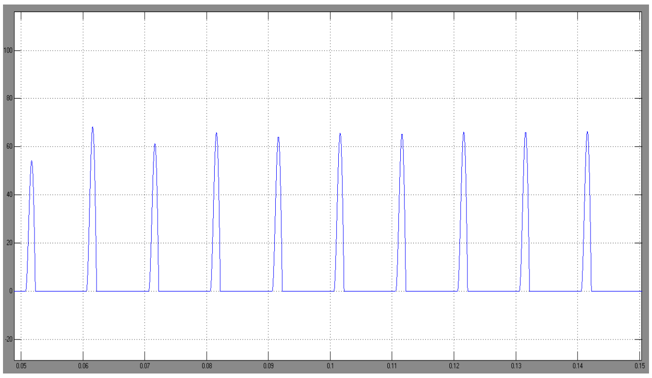

Fig.8. Input Inductor Current

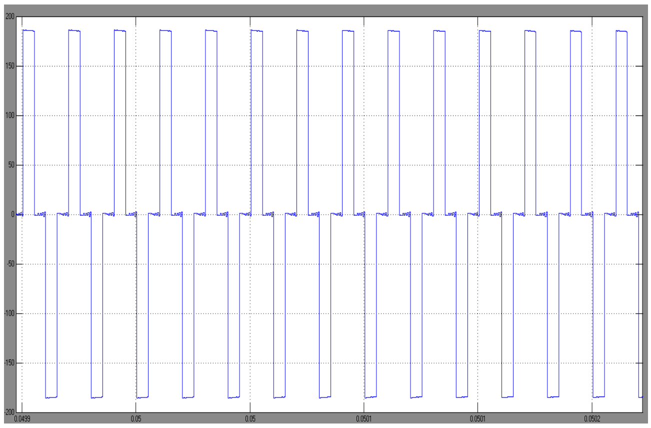

Fig.9. Voltage in Primary Side of Transformer.

Case II Single phase single stage power factor corrected converter for five level inverter.

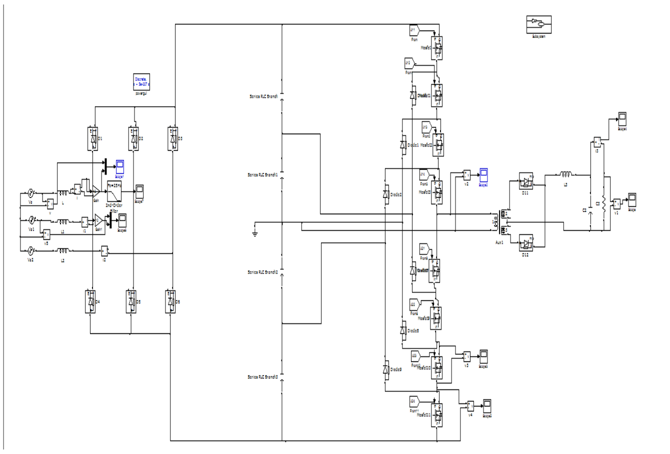

Fig.10. Simulink Circuit for Five Level

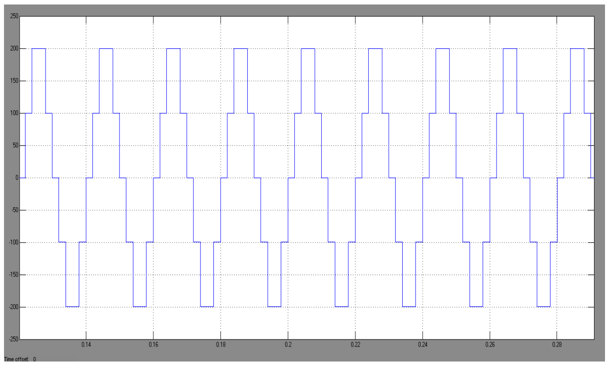

Fig.11. Five Level Output At Primary Side of Transformer.

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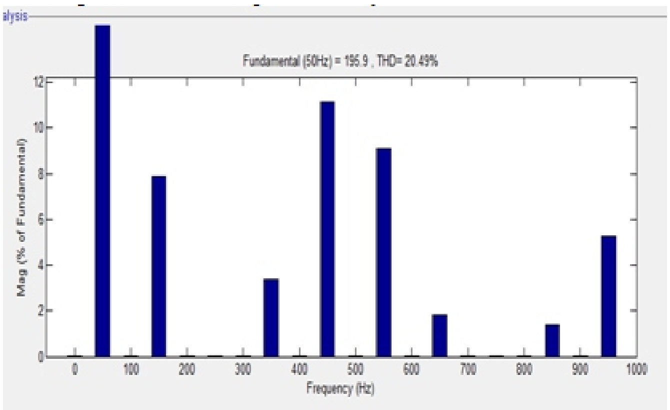

Fig.12.FFT Window for Five Level Output At Primary Side of Transformer

VI.CONCLUSION:

A new single stage three level ac-dc converter, its basic operating principle and design are presented in the paper. The new converter performs both the power factor correction and the voltage regulation in a single stage. It uses two separate controllers for performing power factor correction and output voltage regulation. The summary of the limitations of existing single stage topologies is also presented. The advantageous features of the proposed converter are due to the fact that it is a five-level converter that allows the uncontrolled primary-side dc bus voltage to be higher than what can be allowed for three-level converters. Hence from the outputs of the conventional two stage converter and proposed single stage converter it is clear that power factor is improved and the total harmonic content is reduced with the proposed one. Simulation results obtained from models are also presented to confirm the feasibility of the new converter.

REFERENCES:

[1] IEEE Std. 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems," April 1993.

[2] Limits for Harmonic Current Emissions (Equipment Input Current <16A Per Phase), IEC/EN61000-3-2, 1995.

[3] B. Tamyurek and D. A. Torrey, "A three-phase unity power factor single stage AC–DC converter based on an interleaved fly back topology," IEEE Trans. Power Electron., vol. 26, no. 1, pp. 308– 318, Jan. 2011.

[4] M. Madigan, R. Erickson & E. Ismail, "Integrated High Quality Rectifier Regulators," Proceedings of the Power Electronics Specialists Conference (PESC) 1992, pp. 1043-1051.

[5] G. Moschopoulos and P. Jain, "Single-phase single-stage power factor corrected converter topologies," IEEE Trans. on Ind. Electron., vol. 52, no.1, pp. 23-35, Feb. 2005.

[6] Miaosen Shen and Zhaoming Qian, "A Novel High Efficiency Single Stage PFC Converter with reduced voltage stress" IEEE Transactions on Ind.Electron., vol. 58, no. 2 February 2011.

[7] J. Qian, Q. Zhao & F. Lee, "Single Stage Single Switch Power Factor Correction AC/DC Converters with DC Bus Voltage Feedback for Universal Line Applications," IEEE Transactions on Power Electronics, Vol. 13, No. 6, Nov. 1998, pp. 1079- 1088.

[8] Q. Zhao, F. Lee & F. Tsai, "Voltage and Current Stress Reduction in Single Stage Power Factor Correction AC/DC Converters with Bulk Capacitor Feedback," IEEE Transactions on Power Electronics, Vol. 17, No. 4, July 2002, pp. 477-484.

[9] H. Athab, and D. Lu, "A single-switch ac/dc fly back converter using a CCM/DCM quasi-active power factor correction front-end," IEEE Trans. on Ind. Electron., vol. 59, no. 3., pp. 1517-1526, 2012.

[10] N. Goblin, and G. Moschopoulos, "A low-power ac-dc single-stage converter with reduced dc bus voltage variation", IEEE Trans. on Power Electron., vol. 27, no.8, pp. 3714–3724, Jan. 2012.

[11] T. Wu, J. Hung, S. Tseng & Y. Chen, "A single-stage fast regulator with PFC based on an asymmetrical half-bridge topology," IEEE Transactions on Industrial Electronics, Vol. 52, No. 1, February 2005, pp. 139- 150.

[12] L. Huber, J. Zhang, M. M. Jovanovich & F. C. Lee, "Generalized Topologies of Single Stage Input Current Shaping Circuits," IEEE Transactions on Power Electronics, Vol. 16, No. 4, July 2001, pp. 508–513.