INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

ISSN: 2454-132X

Impact factor: 6.078

(Volume 6, Issue 4)

Available online at: https://www.ijariit.com

Literature Survey on different topologies of UPQC

Vinay Gupta
vinnu56@gmail.com
University Institute of Technology, RGPV, Bhopal, Madhya Pradesh

Shobhna Jain
shobhnajain29bho@gmail.com
University Institute of Technology, RGPV, Bhopal, Madhya Pradesh

ABSTRACT

Concern for power quality issues has been increasing day by day due to increase in renewable energy resources, non-linear loads and applications of power electronic devices. Utility of UPQC to mitigate issues related to power quality is emerging as a universal solution. This paper presents review on various topologies available for UPQC system both for single phase system and three phase system. A review on previous research work on application of UPQC in various utility systems is also showcased.

Keyword: *Unified Power Quality Conditioner (UPQC), Power quality, power electronic converters, dual control strategy, harmonic compensation, voltage sag and swell compensation.*

1. INTRODUCTION

The need for improvement in Power Quality (PQ) issues has shown a steep rise, since the expansion of nonlinear burdens associated with the electrical power framework causing twists in the utility voltages at point of common coupling. The issues related to PQ can be enlisted, such as voltage sags/swells and voltage unbalances can influence the proper operation of sensitive equipment causing malfunction. Furthermore, additional caution must be considered in order to mitigate PQ problems associated with harmonic currents generated by reactive power demand, nonlinear loads and load unbalances.

Since last decade the application of power quality conditioner has been increased on an account of above mentioned problems. High harmonic contents are present in the load current drawn by non-linear loads which induces distortion in the utility voltage resulting in system imbalance.

Poor power quality adversely affects the operation of power system. The power losses will increase interference with nearby communication lines, undesirable behavior and abnormal operation of equipments. Usage of power conditioner [1]-[5] ensures the ripple free operation of power system at the point where it is connected. It smoothen out the harmonic and at the same time draining undistorted currents from the utility grid, even if the grid voltage and the load current have harmonic contents. One such conditioner is Active Power Filter (APF) [6] which is widely used to eliminate harmonics generated by PED. UPQC is one among the family of APF which finds wide spread applications in mitigating power quality issues. The various classifications of UPQC is shown in figure1, and the respective nomenclature is tabulated in Table-1.

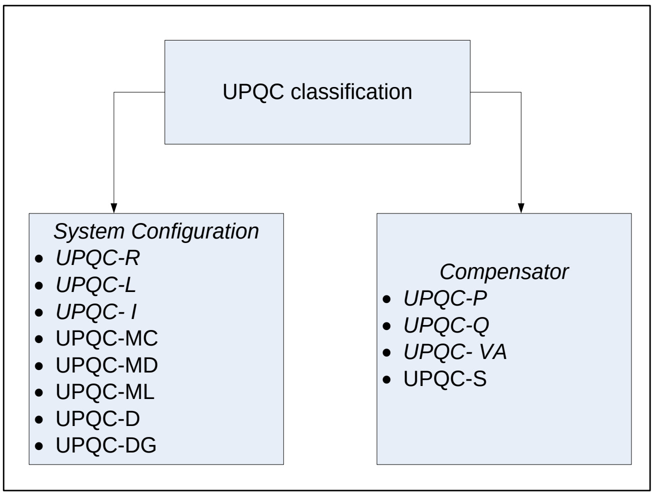

Fig-1 Classification of UPQC

Table 1: Nomenclature for various types of UPQC

UPQC-R	Right shunt UPQC
UPQC-L	Left shunt UPQC
UPQC- I	Interline UPQC
UPQC-MC	Multi converter UPQC
UPQC-MD	Modular UPQC
UPQC-ML	Multi-level UPQC
UPQC-D	Distributed UPQC
UPQC-DG	Distributed generator integrated with UPQC
UPQC-P	Active power controlled UPQC
UPQC-R	Reactive power controlled UPQC
UPQC-VAmin	Minimum VA loading in UPQC
UPQC-S	UPQC mitigates both active power and reactive power

Numerous technologies has been adopted by authors for resolving problems related to PQ issues, which can be carried out by means of active power-line conditioners, such as unified PQ conditioners (UPQCs) [1]–[17], series [18]–[24], shunt [25] and dynamic voltage restorers (APFs) [26], [27], and hybrid active power filters [28].

These topologies find applications in single-phase [18], [19] or three-phase [20]–[24] systems where shunt APFs are placed in parallel with nonlinear loads. In three-phase systems, either series or shunt APF are connected, where there applications are restricted upto compensating load unbalances, harmonic currents [20] or/and load reactive power compensation [21]–[24]. While, UPQC systems can is capable of operating simultaneously as dual compensating device performing the function of both series and parallel APFs. Hence for improving PQ profile, UPQCs have been employed with different concepts and solutions [10], [13], [15], comprising three-phase systems [14] or in single-phase [2], [4], [8], [11], [12].

2. UNIFIED POWER QUALITY CONDITIONER

There are two critical kinds of APF, in particular, shunt APF furthermore, arrangement APF [8] – [10]. The shunt APF is the most encouraging in handling the current-related issues, while, the arrangement APF is the most appropriate to conquer the voltage-related issues. Since the advanced circulation framework requests a superior quality of voltage being provided and current drawn, establishment of these APFs has incredible breadth in real viable usage. Notwithstanding, introducing two separate gadgets to remunerate voltage-and current-related power quality issues, autonomously, may not be a savvy arrangement. Moran [11] depicted a framework design in which both arrangement and shunt APFs were associated consecutive with a typical dc reactor. The topology was tended to as line voltage controller/conditioner. The consecutive inverter framework setup really came into attention when Fujita furthermore, Akagi [14] demonstrated the functional utilization of this topology with 20 kVA test comes about. This combination of series and shunt inverters is nomenclature as UPQC. Fig-2 presents the general structure of UPQC which comprises of source supplied by and renewable energy source or by the utility source two back-back inverters may be current source inverters, voltage source inverters, Multi-level inverters etc. coupled through dc-link voltage. One inverter is connected in parallel through shunt impedance and is connected in series with help of series impedance. One inverter is connected source side another inverter is connected load side. Load may be linear, non-linear, single phase, three phase etc.

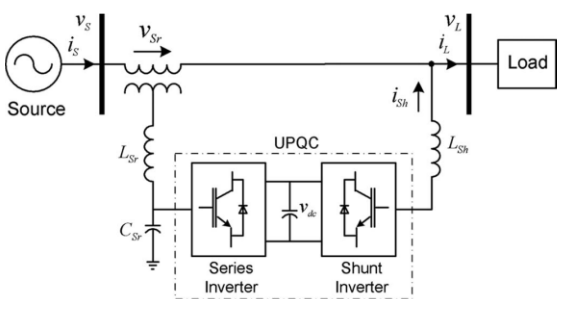

Fig. 2: Basic structure of UPQC

The basic topology has been evolved by researchers in numerous topologies to obtain the desired application. The classification various topologies of UPQC proposed in the literature has been classified in Fig-1. These topologies have been explained in next section.

3. TOPOLOGIES OF UPQC

The control of dc-link voltage assumes a vital part in accomplishing the coveted UPQC execution. Amid the framework dynamic conditions, for instance, sudden load change, voltage droop, the dc-connect input controller ought to react as quick as conceivable to reestablish the dc-interface voltage at set reference esteem, with least deferral and additionally bring down overshoot. In literature various control strategies are available to tune the dc-link voltage and to achieve the desired controls for PQ issues which have been discussed in brief here.

3.1 UPQC-R and UPQC-L

Right and Left shunt UPQC, since UPQC consist of two converters either can be shunted, so when right converter is shunted its termed as UPQC-R as shown in Fig-2 and when left converter is shunted it is termed as UPQC-L. As shown in Fig-3. In UPQC-R, the current(s) that move through arrangement transformer is (are) mostly sinusoidal independent to the idea of load current on the framework (given that the shunt inverter repays current music, responsive current, unbalance, and so forth, successfully). In this way, UPQC-R gives a superior general UPQC execution contrast with UPQC-L. The UPQC-L structure is here and there utilized as a part of unique cases, for instance *to* avoid the interference between the shunt inverter and passive filters.

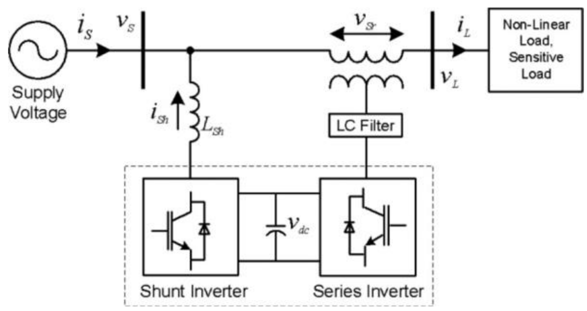

Fig. 3: UPQC-L

3.2 UPQC-I

When the two inverters of the UPQC are interlinked between two feeders the resulting configuration is known as interline UPQC (UPQC-I). Among the two inverters one is connected in series and another in parallel with the two feeders of the distribution network. This configuration assists the control of voltage of both the feeders simultaneously. Also UPQC-I is capable to control the flow of active power among the feeders. Figure 4.

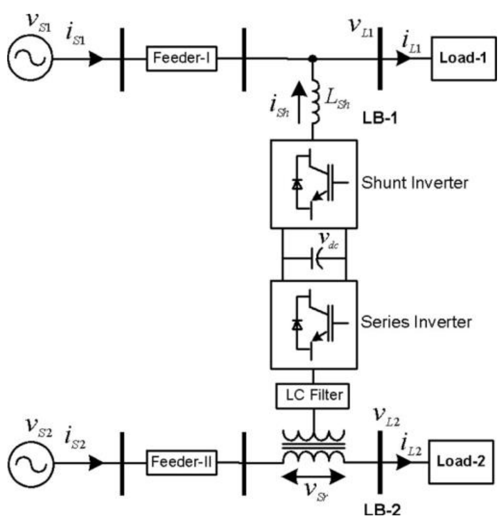

Fig. 4: UPQC-I

3.3 UPQC-MC
Third converter is Furthermore connected in the existing UPQC configuration to support the Dc bus voltage is known as UPQC-MC (Fig-5). The third converter can either be connected in series or in parallel with one of the converter and with the feeder.

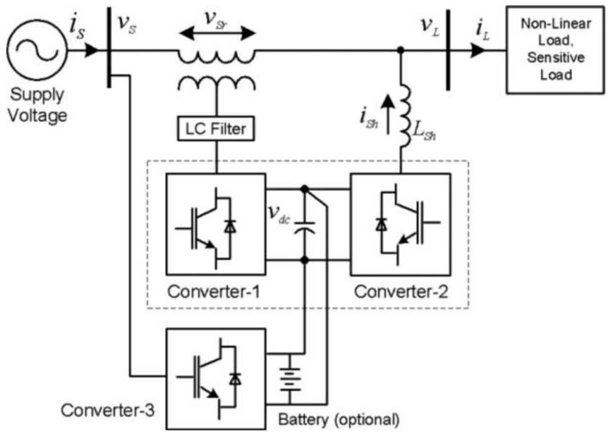

Fig. 5: UPQC-MC

3.4 UPQC-M
The cascaded H-Bridge MLI is used as the two converter to design modular UPQC topology as shown in Fig-6. In [27] and [28], the H-bridge modules for shunt part of UPQC are connected in series through a multi-winding transformer, while the H-bridges in the series part are directly connected in series and inserted in the distribution line without a series injection transformer.

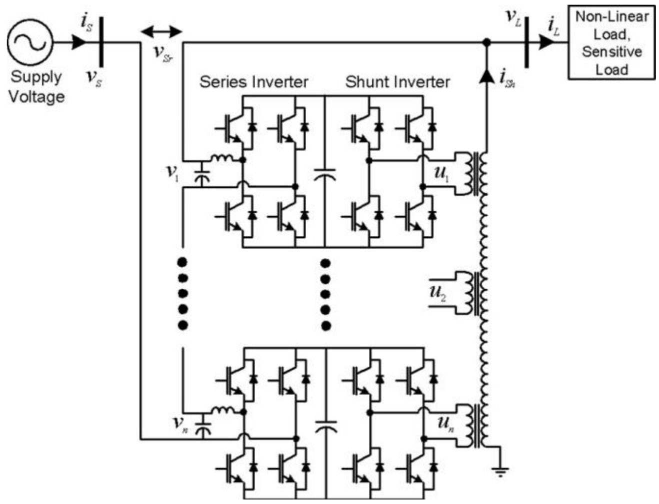

Fig. 6: UPQC-MD

3.5 UPQC-ML
To design UPQC-ML neutral point clamped MLI is used in place of series and shunt inverter as shown in Fig-7.

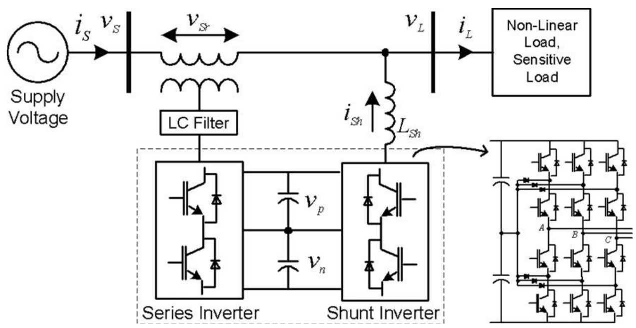

Fig. 7: UPQC-ML designed using Neutral point clamped MLI

3.6 UPQC-D
The UPQC used to resolve PQ issues in three phase three wire and three phase four wire distribution network is called as UPQC-D as shown in fig-8. A 3P4W distribution system is generally realized by providing a neutral conductor along with the three power lines from substation or by utilizing a delta–star transformer at the distribution level [29-30].

3.7 UPQC-DG
UPQC employed to integrate one or more distributed generations like solar, wind, etc. with the utility grid is called UPQC-DG. The DG power can be regulated and managed through UPQC to supply to the loads connected to the PCC in addition to the voltage and current power quality problem compensation [31-36]. This topology of UPQC is very popular among the researchers of renewable energy resources and being widely used to mitigate the PQ issues like current harmonics, voltage flickers, real and reactive power compensation, etc. Fig-9 presents the topology for UPQC-DG.

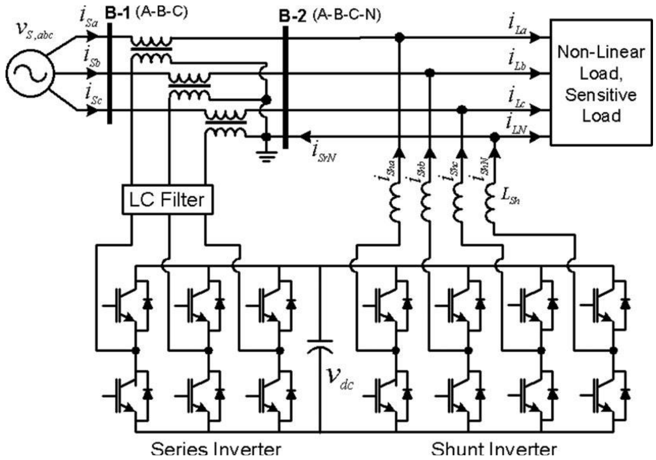

Fig. 8: UPQC-D

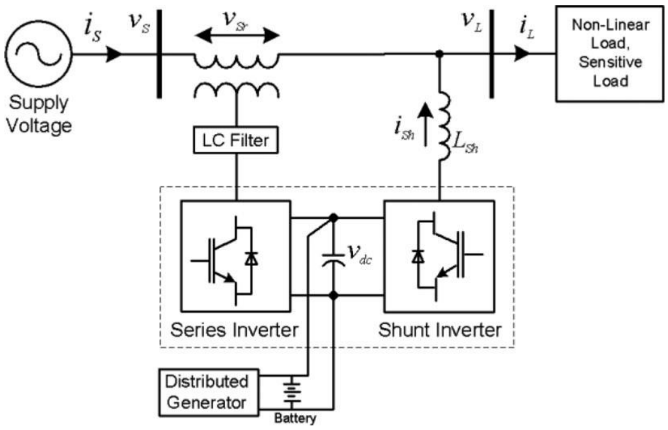

Fig. 9: UPQC-DG

4. CONCLUSION
This paper presents a comprehensive review on wide topologies of UPQC. A detailed classification and brief description of the various UPQC available in literature has been showcased depending upon their utility in the system it is connected. The increased penetrations of renewable resources into the existing grid alter the grid profile and adversely effects the sensitive equipments connected. The application of UPQC to integrate RES into the utility system may resolve many power quality issues which has been briefly discussed in this paper.

5. REFERENCES

[1] [1] R. C. Dugan, M. F. McGranaghan, and H. W. Beaty, Electrical Power Systems Quality. New York: McGraw-Hill, 1996.
[2] C. Sankaran, Power Quality. Boca Raton, FL: CRC Press, 2002.
[3] IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, IEEE Standard 519-1992, 1992.
[4] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE Standard 1547-2003, 2003.
[5] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. New York: Institute of Electrical and Electronics Engineers, 2000.
[6] V. K. Sood, HVDC and FACTS Controllers—Applications of Static Converters in Power Systems. Boston, MA: Kluwer, 2004.
[7] A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Boston, MA: Kluwer, 2002.
[8] H.Akagi, "Trends in active power line conditioners," IEEE Trans. Power Electron., vol. 9, no. 3, pp. 263–268, May 1994.
[9] B. Singh, K. Al-Haddad, and A. Chandra, "A review of active filters for power quality improvement," IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.
[10] M. El-Habrouk, M. K. Darwish, and P. Mehta, "Active power filters: A review," IEE Electr. Power Appl., vol. 147, no. 5, pp. 403–413, Sep. 2000.
[11] S. Moran, "A line voltage regulator/conditioner for harmonic-sensitive load isolation," in Proc. Ind. Appl. Soc. Annu. Meet. Conf., Oct. 1–5, 1989, pp. 947–951.
[12] F. Kamran and T. G. Habetler, "Combined deadbeat control of a series parallel converter combination used as a universal power filter," in Proc. Power Electron. Spec. Conf., Jun. 18–22, 1995, pp. 196–201. 2294 IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 27, NO. 5, MAY 2012
[13] S. Muthu and J. M. S. Kim, "Steady-state operating characteristics of unified active power filters," in Proc. Appl. Power Electron. Conf., Feb. 23–27, 1997, pp. 199–205.
[14] H. Fujita and H. Akagi, "The unified power quality conditioner: The integration of series and shunt-active filters," IEEE Trans. Power Electron., vol. 13, no. 2, pp. 315–322, Mar. 1998.
[15] B. N. Singh, A. Chandra, K. Al-Haddad, and B. Singh, "Fuzzy control algorithm for universal active filter," in Proc. Power Quality Conf., Oct. 14–18, 1998, pp. 73–80.
[16] M. Aredes,K.Heumann, and E.H.Watanabe, "An universal active power line conditioner," IEEE Trans. Power Del., vol. 13, no. 2, pp. 545–551, Apr. 1998.
[17] M. C. Wong, C. J. Zhan, Y. D. Han, and L. B. Zhao, "A unified approach for distribution system conditioning: Distribution system unified conditioner (DS-UniCon)," in Proc. Power Eng. Soc. Winter Meet., Jan. 23–27, 2000, pp. 2757–2762.
[18] M. Hu and H. Chen, "Modeling and controlling of unified power quality conditioner," in Proc. Adv. Power Syst. Control, Operation Manage., Oct. 30–Nov. 1, 2000, pp. 431–435.
[19] D. Graovac, V. Katic, and A. Rufer, "Power quality compensation using universal power quality conditioning system," IEEE Power Eng. Rev., vol. 20, no. 12, pp. 58–60, Dec. 2000.
[20] Y. Chen, X. Zha, J. Wang, H. Liu, J. Sun, and H. Tang, "Unified power quality conditioner (UPQC): The theory, modeling and application," in Proc. Int. Conf. Power Syst. Technol., 2000, pp. 1329–1333.
[21] S. Chen and G. Joos, "Rating issues of unified power quality conditioners for load bus voltage control in distribution systems," in Proc. Power Eng. Soc. Winter Meet., 28 Jan.–1 Feb., 2001, pp. 944–949.
[22] S. Chen and G. Joos, "A unified series–parallel deadbeat control technique for an active power quality conditioner with full digital implementation," in Proc. IEEE 36th Ind. Appl. Soc. Annu. Meet. Ind. Appl. Conf., 30 Sep.–4 Oct., 2001, pp. 172–178.
[23] M. Basu, S. P. Das, and G. K. Dubey, "Experimental investigation of performance of a single phase UPQC for voltage sensitive and nonlinear loads," in Proc. 4th IEEE Int. Conf. Power Electron. Drive Syst., Oct. 22–25, 2001, pp. 218–222.
[24] A. Elnady, A. Goauda, and M. M. A. Salama, "Unified power quality conditioner with a novel control algorithm based on wavelet transform," in Proc. Can. Conf. Electr. Comput. Eng., 2001, pp. 1041–1045.
[25] A. Elnady and M. M. A. Salama, "New functionalities of an adaptive unified power quality conditioner," in Proc. Power Eng. Soc. Summer Meet., 2001, pp. 295–300.
[26] B. S. Chae, W. C. Lee, D. S. Hyun, and T. K. Lee, "An overcurrent protection scheme for series active compensators," in Proc. 27th Annu. Conf. IEEE Ind. Electron. Soc., 2001, pp. 1509–1514.
[27] E. H. Watanabe and M. Aredes, "Power quality considerations on shunt/series current and voltage conditioners," in Proc.10th Int. Conf. Harmonics Quality Power, Oct. 6–9, 2002, pp. 595–600.
[28] A. Pievatolo, E. Tironi, I. Valade, and G. Ubezio, "UPQC reliability analysis," in Proc. 10th Int. Conf. Harmonics Quality Power, Oct. 6–9, 2002, pp. 390–397.
[29] P. Rodriguez, L. Sainz, and J. Bergas, "Synchronous double reference frame PLL applied to a unified power quality conditioner," in Proc. 10^{th} Int. Conf. Harmonics Quality Power, Oct. 6–9, 2002, pp. 614–619.
[30] J. Prieto, P. Salmeron, J. R. Vazquez, and J. Alcantara, "A series–parallel configuration of active power filters for VAr and harmonic compensation," in Proc. IEEE 28th Annu. Conf. Ind. Electron. Soc., Nov. 5–8, 2002, pp. 2945–2950.
[31] A. Elnady, W. El-khattam, and M. M. A. Salama, "Mitigation of AC arc furnace voltage flicker using the unified power quality conditioner," in Proc. Power Eng. Soc. Winter Meet., 2002, pp. 735–739.
[32] M. T. Haque, T. Ise, and S. H. Hosseini, "A novel control strategy for unified power quality conditioner (UPQC)," in Proc. Power Electron. Spec. Conf., 2002, vol. 1, pp. 94–98.
[33] G. Jianjun, X. Dianguo, L. Hankui, and G. Maozhong, "Unified power quality conditioner (UPQC): The principle, control and application," in Proc. Power Convers. Conf., 2002, pp. 80–85.
[34] L. H. Tey, P. L. So, and Y. C. Chu, "Neural network-controlled unified power quality conditioner for system harmonics compensation," in Proc. IEEE/PES Transmiss. Distrib. Conf. Exhib., 2002, pp. 1038–1043.
[35] R. Faranda and I. Valade, "UPQC compensation strategy and design aimed at reducing losses," in Proc. IEEE Int. Symp. Ind. Electron., 2002, pp. 1264–1270.

[36] L. F. C. Monteiro, M. Aredes, and J. A. Moor Neto, "A control strategy for unified power quality conditioner," in Proc. Int. Symp. Ind. Electron., Jun. 9–11, 2003, pp. 391–396.

[37] M. Correa, S. Chakraborty, G. Simoes, and A. Farret, "A single phase high frequency ACmicrogrid with an unified power quality conditioner," in Proc. IEEE Int. Symp. Ind. Electron., Jun. 9–11, 2003, pp. 956–962.

[38] J. Liu, Y. He, Y. Ye, and X. Wang, "An unified scheme and respective algorithms for the control of DC-linked double converters in an universal power quality controller," in Proc. Power Electron. Spec. Conf., Jun. 15– 19, 2003, pp. 327–332.