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Two switches based AC-link phase-shifter

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Abstract: This work proposes a PWM quadrature phase shifter which uses only two driven switches. The PWM control is based on DC signals asynchronous from the grid, free of PLL and trigonometric calculations, the control can be accomplished with a low-cost micro controller.

Keywords: AC-AC power conversion, phase shifters, FACTS
Classification: Electron devices, circuits, and systems

References

[1] J. C. Rosas-Caro, J. M. Ramirez, and F. Z. Peng, "Simple topologies for AC-link flexible AC transmission systems," *Proc. 2009 Bucharest PowerTech Conference*, pp. 1–8.
[2] G. Venkataramanan, "Three-phase vector switching converters for power flow control," *IEE Proceedings - Electric Power Applications*, vol. 151, no. 3, pp. 321–333, May 2004.
[3] J.-H. Kim and B.-H. Kwon, "Three-phase ideal phase shifter using AC choppers," *IEE Proceedings - Electric Power Applications*, vol. 147, no. 4, pp. 329–335, July 2000.
[4] F. Mancilla-David, S. Bhattacharya, and G. Venkataramanan, "A Comparative Evaluation of Series Power-Flow Controllers Using DC- and AC-Link Converters," *IEEE Trans. Power Del.*, vol. 23, no. 2, pp. 985–996, April 2008.
[5] J. C. Rosas-Caro, R. Castillo-Gutierrez, J. E. Flores-Hernandez, J. A. Hernandez-Muñoz, F. A. Garcia-Santiago, and J. E. Martinez-Bernal, "Two switches based AC-link phase-shifter," *2010 12th International Power Electronics Congress (CIEP)*, pp. 29–32, Aug. 2010.

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Two-switch three-phase ac-link dynamic voltage restorer

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Abstract: This study presents a topology for a pulse width modulated (PWM) three-phase voltage regulator that uses only two driving switches, providing high reliability and making the switching stage simpler and cheaper compared with other available configurations. The proposed topology is suitable for voltage regulation on the distribution power system. It is able to regulate the steady-state voltage and to reject voltage variations such as flicker or sags caused by large motors start. In addition, the compensator features a topology free of energy storage elements. The PWM control is based on dc signals, asynchronous from the grid, simpler than the control used for traditional voltage source converters – it does not require a phase-locked loop, and does not involve trigonometric calculations. As a result of this, the controller can be achieved with an analogue controller or a low-cost microcontroller. The proof of concept is performed with a 220 V three-phase voltage regulator, which is simulated and prototyped in the laboratory.

1 Introduction

Under the rubric of custom power (CP), power electronics bring the promise of providing enhanced reliability and power quality levels to the distribution system [1]. The realisation of power conditioning systems may be divided into two approaches according to their power stage architecture: (i) the dc-link approach, based on either a voltage source converter (VSC) or a current source converter depending on the energy storage device being a capacitor or an inductor, respectively, and (ii) the ac-link approach, based on ac–ac converters without energy storage [2–4]. Comparative studies between the two approaches have appeared in the literature, reporting on the various tradeoffs involved in the realisations [5].

The state-of-the-art technology for voltage regulation in the distribution system has been termed dynamic voltage restorer (DVR). The power stage of a DVR includes a dc-link VSC that connects in series with a sensitive load through an injection transformer, providing premium quality voltage to the load of interest [6, 7]. Several ac-link power conditioning systems have been proposed in the literature [8–13], where the advantages against their dc-link counterparts have been discussed. A main advantage at the power stage is the operation without energy storage. At the control stage the modulation of ac-link converters is realised with dc signals asynchronous from the grid, which allows for operating without the need of a phase-locked loop (PLL) and makes the control scheme immune to frequency and phase jumps in the ac grid. A design oriented comparative evaluation between ac- and dc-link power flow series compensators at the transmission level has reported several additional advantages of ac-link compensators, including lower size, cost and power semiconductor rating for the same amount of compensation level [5].

The literature review suggests that ac-link power converters for voltage regulation may be further classified into two main groups: Type 1 – those using an ac-link converter rated at full throughput power [8, 9] and Type 2 – those realised using ac-link converters along with injection transformers. In the latter approach the converter is rated at only a fraction of the throughput power [10, 11, 14]. Figs. 1*a* and *b* show an example of an ac-link buck converter for each type. Boost as well as buck–boost topologies may also be realised. Indeed, ac-link converters can be derived from the well known dc–dc converter topologies. Efforts for unifying these ideas have appeared in the literature in the context of CP [15], flexible ac transmission systems [16] and as power flow control gateways in complex networks [17].

This paper proposes a novel pulse width modulated (PWM) ac-link converter topology that may perform as a DVR. The topology requires an ac–ac converter with only two driving switches and two injection transformers, and hence belongs to the Type 2 class defined above. In addition, the topology

Dynamic voltage restorers based on AC-AC topologies

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***Abstract*—The matrix converter (MC) and the Vector Switching Converter (VeSC) are employed as the building block in order to assemble a couple of dynamic voltage restorers (DVR). Their operating principles are reviewed and their performances under sag events are studied. Results are presented on small-scale prototypes.**

***Index Terms*—ac-ac converter, custom power, power electronics, distribution systems.**

I. INTRODUCTION

THE dynamic voltage restorer (DVR), with both DC–link and AC–link, has been extensively reviewed. The modeling has been carried out both in *abc*–coordinates [1] and in *dq*–coordinates. The latter exhibits a simplified control design for balanced voltage sags mitigation [2]. For both types of links, considerations concerning with the DVR's connection have been deeply studied, [1], [3].

The DC–link–based DVR has been widely studied and represents the state–of–the–art of the Custom Power (CP) devices. When a DC–link is employed the required voltage used for restoring the load voltage may be obtained by means of pulse width modulation (PWM), multilevel, or multipulse inverter. In this case, it is easy to synthesize the required AC voltage [3]. However, the storage energy device requires provide the amount of energy that depends on the voltage sag depth. Hence, for large voltage sag a voluminous capacitor is needed [4].

On the other hand, the first application of an AC–AC converter was made by the well–known naturally commutated cycloconverters (NCC) [4]. As its name implies, it uses naturally commutated switches, such as SCR and TRIAC. With the improvement of the semiconductor technology [5]–[6], devices with forced–commutation capability, such as IGBT, GTO, and IGCT, have arisen making possible the matrix converter (MC) realization. Given its suitable features, the (MC) has been used as a building block in the DVR assembling. Several DVR's topologies have been reported in order to attain different purposes. For instance: (*i*) unbalanced voltage sag [7]-[8], (*ii*) flicker problem mitigation [9], (*iii*) flywheel as storage element coupled to a matrix converter for balanced voltage was already presented [10].

Likewise, there are topologies with energy storage. A capacitor has been used as a storage energy device which voltage can be controlled by allowing a small amount of active power flowing from the distribution system. However, this configuration presents a relatively poor performance for severe and long duration voltage sags. A flywheel can be used as a storage energy device for the AC–link. Adding a power electronic converter the link can be regulated by the DC– and AC–link, respectively.

Similarly, topologies without energy storage that use the energy from the system itself have been presented as well. The shunt connection can be made from the point of common coupling (PCC) side or from the load side. Within the schemes fed from the PCC side, the links are affected when a voltage sag/swell occurs; this is overcome in the load side–connected configurations.

In this paper, two DVRs based on AC-AC converters are presented: (*i*) one is based on a Matrix Converter (MC); (*ii*) the second one is based on the Vector Switching Converter (VeSC). Both devices were assembled for different criterions and institutions, so that they are not compared but they are presented as a good choice for building block in the DVR implementation.

II. DVR BASED ON THE MATRIX CONVERTER

A matrix converter (MC) is an energy conversion device which directly connects a three-phase voltage source to a three-phase load without DC-link components. The MC is a single-stage converter, which directly connects one phase of the input to one phase of the output without needing intermediate energy storage components. This topology of AC-AC converters was first proposed by Gyugyi and Pelly in 1976 to obtain an unlimited output frequency [11]. In 1980, a generalized high-frequency switching strategy was proposed by Venturini [12]; this single-stage converter was named *matrix converter*. After the optimum-amplitude method had been proposed by Venturini and Alesina in 1989 [13], the matrix converter received an increased amount of interest [14], [15]. The majority of MC use naturally commutated silicon-controlled rectifiers for their operation when the maximum output frequency is limited to a fraction of the input frequency.

Some advantages of the matrix converters are [16-20]:

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CONFIGURACIÓN DE DOS CONVERTIDORES VECTORIALES EN CASCADA PARA APLICACIONES EN ACONDICIONADORES DE POTENCIA

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RESUMEN

Este artículo presenta un algoritmo para la conmutación de dos convertidores vectoriales (VeSC) configurados en cascada empleados para la realización de un Restaurador Dinámico de Voltaje (DVR), el cual es uno de los dispositivos más populares y con mayor aceptación dentro de los acondicionadores de potencia. Dicho DVR tiene como objetivo principal mitigar desbalances en el voltaje de carga de un sistema trifásico, el problema es abordado mediante la técnica de descomposición de componentes simétricas. Como resultado, se obtienen dos sets de voltajes que son generados por dos convertidores que comparten el transformador de entrada. La conexión ha sido validada mediante los modelos correspondientes de cada uno de los convertidores alimentados del mismo transformador. Sin embargo, inconvenientes se presentan en la implementación física cuando los modelos son implementados con semiconductores reales. La forma de controlar los pulsos en las compuertas de los elementos de control es revisada y un algoritmo para la apropiada conmutación es propuesto. Resultados de laboratorio del sistema final corroboran el correcto funcionamiento.

INTRODUCCIÓN

Las normas vigentes sobre la calidad de energía (IEEE, 1995), aunados con la poca tolerancia de algunos dispositivos en la industria, conlleva a la creación de nuevos topologías correspondientes a los miembros de la familia de acondicionadores de potencia (custom power devices) [2] que satisfagan los requerimientos en la calidad de energía. Dichos dispositivos fueron introducidos por EPRI (Electric Power Research Institute) (Hingorani, 2005), a mediados de los 80s; las configuraciones más destacadas son la conexión en (i) derivación o compensador estático para distribución (DSTATCOM), (ii) la conexión en serie denominado restaurador dinámico de voltaje (DVR, dynamic voltage restorer) y (iii) la conexión mixta en el dispositivo conocido como controlador unificado de calidad de energía (UPQC, unified power quality controller) el cual combina las mejores características de los dos anteriores (Ghosh, 2005; Domijan, 2005; Khadkikar, 2012).

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On the experimental implementation of a nonlinear adaptive observer

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Abstract: This paper deals with the implementation of an output current estimator for a DC-DC Multiplier Boost Converter (MBC). For that purpose, a real time platform is used for solving the dynamic equations of a nonlinear adaptive observer. Excellent performance is achieved even during demanding conditions. In particular, a reliable estimation is obtained when an experimental nonlinear dynamic system is utilized as an electric load connected at the converter terminals.

Keywords: dynamic model, nonlinear observer, converter

Classification: Electron devices, circuits, and systems

References

[1] J.C. Mayo-Maldonado, R. Salas-Cabrera, J.C. Rosas-Caro, J. De-Leon-Morales, and E.N. Salas-Cabrera, "Modeling and Control of a DC-DC Multilevel Boost Converter," *Power Electronics IET*, vol. 4, no. 6, pp. 693–700, July 2011.

[2] Knoppix 5.0.1, Open source Linux distribution, [Online] http://iso.linuxquestions.org/knoppix/knoppix-5.0.1/

[3] [Online] http://www.rtai.org/RTAILAB/

[4] A. Gensior, J. Weber, J. Rudolph, and H. Guldner, "Algebraic Parameter Identification and Asymptotic Estimation of the Load of a Boost Converter," *IEEE Trans. Ind. Electron.*, vol. 55, no. 9, pp. 3352–3360, Sept. 2008.

[5] J. Linares-Flores, J. Reger, and H. Sira-Ramirez, "Load Torque Estimation and Passivity-Based Control of a Boost-Converter/DC-Motor Combination," *IEEE Trans. Contr. Syst. Technol.*, vol. 18, no. 6, pp. 1398–1405, Nov. 2010.

[6] J.C. Mayo-Maldonado, R. Salas-Cabrera, J. de-Leon-Morales, E.N. Salas-Cabrera, R. Castillo-Gutierrez, J.E. Martinez-Bernal, and D. Soto-Monterrubio, "On the output current estimation of a DC-DC mul-

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