Synchronous control of indirect matrix converter for three-phase power conditioner

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A B S T R A C T

This paper describes an average model of indirect matrix converter (IMC) with an output LC filter in stationary and rotating reference frames. The developed model is non-linear and should be linearized in order to design linear controllers. Transient performance of the IMC is compared with that of conventional inverter in classic AC/DC/AC system. In order to make the IMC applicable for power conditioner applications a synchronous controller is designed. A power conditioner acts in one or more ways to deliver a voltage of the proper level and characteristics to enable load equipment to function properly. In order to afford the power conditioner requirements the controller has two segments. One segment controls the IMC with balanced input supply voltage and the other controls the system with unbalanced input supply voltage. The system can provide balanced output voltages with slight distortion of line side currents. Theory analyses, the model validation and simulation results are presented to verify the effectiveness of this control method.

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1. Introduction

A variety of circuit topologies using solid state switches have been developed to convert AC power at one frequency to AC power at another. One type of topologies, known as conventional matrix converter (CMC) and first introduced in 1979 [1] (Fig. 1), can directly convert AC to AC, rather than AC to DC to AC as in many conventional converters. CMCs hold many advantages, including an adjustable input power factor, bidirectional power flow, high-quality power output waveforms, and the potential for a more compact product because they do not require a large energy storage compartment, such as a DC bus capacitor. Despite these benefits, however, the CMC has not been adopted by industry. This is mainly because of the modulation algorithm of these converters switch requires a complex and difficult pulse width modulation (PWM) switching strategy being prone to commutation failure. An alternative topology for AC/AC conversion, known as indirect matrix converter (IMC) topology, is shown in Fig. 2. The IMC consists of two separated line and load bridges and offers the same benefits as the CMC, but it also provides an option to reduce the number of active switches of the line bridge to three if no bidirectional power flow is needed and eliminates the commutation problems related to CMCs [2–5]. Several papers have been published to illustrate this topology. In [2], this topology is treated as a rectifier/inverter, in which line and load side switches are controlled separately. Reports [3–5] treat this topology as a type of matrix converter. In them, a detailed PWM control method is proposed with synchronized switching of the both line and load side switches. Zero current commutation of line side switches is also analyzed. The absence of DC link has two main disadvantages: first, unfiltered input and output disturbances are carried through matrix converters and second, additional commutation strategies are needed to avoid a short-circuiting of the supply and/or a cutting of the load current path. The output–input voltage ratio is also limited to 0.866 in linear modulation range [6]. Indirect matrix converter with abnormal supply conditions has been studied, e.g., in [7,8]. In [7] the main principle is to decompose unbalanced control switching function into line side and load side converters individually.

In [9–11] the application of an IMC in induction motor and permanent magnet synchronous motor (PMSM) drive is investigated, respectively. In these applications, the output of the converter is connected directly to the motor terminals. However in some applications, there is an output LC filter between load and converter. A power conditioner is one of these applications. A power conditioner or automatic voltage regulator (AVR) can correct power quality problems, like brownouts, surges, over-voltage, sags, voltage imbalance, unbalanced current, line noise and other issues that cost business billions of dollars each year. In other words, a power conditioner acts in one or more ways to deliver a voltage...