Predictive Current Control for Three-Level Four-Leg Indirect Matrix Converter under Unbalanced Input Voltage

Hazrul Mohamed Basri, *Senior Member, IEEE*, Saad Mekhilef, *Fellow IEEE*

***Abstract*— In this paper, a robustness evaluation of model predictive current control with instantaneous reactive power minimization for a three-level four-leg indirect matrix converter is presented. Unbalanced voltages can be extremely dangerous, especially for motors and other inductive equipment. Unbalanced voltages can have a detrimental effect on equipment and the power system, which is exacerbated by the fact that a small phase voltage imbalance can result in a disproportionately large phase current imbalance. The robustness test is carried out by considering balance and unbalanced input voltages. The proposed control predicts the behavior of the load current and the instantaneous reactive power for every possible 96 switching states. Subsequently, it selects the optimum switching state which fulfils the objectives of the control without the need of modulators. The cost function has been adequately modified to consider the asymmetrical aspect of the input voltage. Experimental validation using a laboratory prototype was conducted by using FPGA under a wide range of input voltage unbalance. The experimental results show high fidelity load current reference tracking while maintaining relatively low instantaneous reactive power during the transient and steady-state condition. The percentage of reactive power after setting the optimal weighting factor, the average reactive power was found to reduce to approximately 10-20%.**

***Index Terms*— AC-AC converters, Multilevel converters, Predictive Control.**

I. Introduction

THE proposed system seeks to resolve two critical issues of ac/ac conversion which are unbalance input voltage and unbalanced loading condition. For the four-leg ac/ac converter, the unbalance may originate from two distinct sources which are the supply side and the load side. The supply voltages are assumed to be perfectly sinusoidal by most of the control techniques. However, the assumption is not always true. It is more likely for the supply voltage to be nearly non-sinusoidal, unbalanced and distorted which may affect the output waveforms and significantly increase the reactive power. In a practical electrical a.c system, power can be termed as active and reactive power. The reactive power is not a usable power that can be converted into heat movement or light. The reactive power is due to the capacitors in electronics components and magnetism in motors and transformers. When the network voltages are unbalanced, negative-sequence voltages and currents appear, which can significantly increase the total apparent power supplied by the network [1]. Increased reactive power equates to increased power flowing through the installation. Increased current flowing through the installation results in increased losses due to the installation's impedance. This issue can be resolved by minimizing the reactive power. The reduction of reactive power may improve the power factor which leads in less current being drawn, resulting in lower electricity bills, reduced heat, and increased electrical system longevity. As a result, the installation reduces the maximum demand tariff, lowering your power expenditures.

[2] performs a case study for 782 low voltage substations and based on the case study, 72.8% experience unbalanced issues. This paper mitigates voltage imbalance by proposing a voltage support control strategy. This technique maximizes the positive voltage sequence while minimizing the negative voltage sequence. Voltage imbalances are one of the most severe challenges in electrical networks, which negatively affect their loads and other connected equipment [2], [3]. Unbalanced voltages can have a negative impact on both devices and the power system. It magnifies a minor phase voltage imbalance into a disproportionately bigger phase current imbalance[4]. Under unbalanced situations, the power system will experience increased losses and heating impacts, as well as decreased stability, because a balanced system is better equipped to react to emergency load transfers [5]. There are numerous reasons for imbalanced voltages, including unbalanced incoming supply of utilities, uneven tap settings on transformers, power transformer faults, or conductors of power supply wiring have unequal impedance. But, unbalanced load distribution and random load behavior are two of the primary causes of three-phase power imbalance.

Therefore, it is important to maintain the desired sinusoidal output waveform throughout transient and steady state conditions. Unbalance current distributions through each load stem from unbalanced loads. For that reason, the conventional six switches three-phase systems are inappropriate for

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Hazrul Mohamed Basri, is with Universiti Malaysia Sarawak, 94300, Sarawak, Malaysia (e-mail: mbhazrul@unimas.my).

Saad Mekhilef is with the School of Science, Computing and Engineering Technologies, Swinburne University of Technology, Hawthorn, VIC 3122, Australia, Power Electronics and Renewable Energy Research Laboratory, Department of Electrical Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia and Department of Electrical Engineering, College of Engineering, Universiti Tenaga Nasional, Selangor, Malaysia (e-mail:smekhilef@swin.edu.au)