A simplified synchronous reference frame for indirect current controlled three-level inverter-based shunt active power filters

ABSTRACT

This paper presents a new simplified harmonics extraction algorithm based on the synchronous reference frame (SRF) for an indirect current controlled (ICC) three-level neutral point diode clamped (NPC) inverter-based shunt active power filter (SAPF). The shunt APF is widely accepted as one of the most effective current harmonics mitigation tools due to its superior adaptability in dynamic state conditions. In its controller, the SRF algorithm which is derived based on the direct-quadrature (DQ) theory has played a significant role as a harmonics extraction algorithm due to its simple implementation features. However, it suffers from significant delays due to its dependency on a numerical filter and unnecessary computation workloads. Moreover, the algorithm is mostly implemented for the direct current controlled (DCC) based SAPF which operates based on a non-sinusoidal reference current. This degrades the mitigation performances since the DCC based operation does not possess exact information on the actual source current which suffers from switching ripples problems. Therefore, three major improvements are introduced which include the development of a mathematical based fundamental component identifier to replace the numerical filter, the removal of redundant features, and the generation of a sinusoidal reference current. The proposed algorithm is developed and evaluated in MATLAB/Simulink. A laboratory prototype utilizing a TMS320F28335 digital signal processor (DSP) is also implemented to validate effectiveness of the proposed algorithm. Both simulation and experimental results are presented. They show significant improvements in terms of total harmonic distortion (THD) and dynamic response when compared to a conventional SRF algorithm.