Energy Reports 8 (2022) 3323–3336

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Research paper

Improved power quality operation of symmetrical and asymmetrical multilevel inverter using invasive weed optimization technique

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ARTICLE INFO

Article history:
Received 10 October 2021
Received in revised form 29 December 2021
Accepted 16 January 2022
Available online 2 March 2022

Keywords:
Multilevel inverter
Low switching frequency
Invasive weed optimization
FPGA
Total harmonics distortion

ABSTRACT

Low switching frequency pulse width modulation (PWM) technique for modulation and control of multilevel inverter in medium voltage high power applications is preferred in order to reduce the switching losses. In this context, a multilevel inverter operated with Selective harmonics minimization PWM technique offers better quality waveform at reduced switching losses. After the Fourier series analysis, the system of non-linear simultaneous transcendental equations is obtained. These equations are then solved to obtain switching angles to have certain low order harmonics at minimum value and regulation in the fundamental voltage magnitude. In this paper, a novel invasive weed optimization (IWO) technique is proposed to compute switching angles. The proposed technique can compute switching angles for both symmetrical and asymmetrical multilevel inverters. Thus it has superiority over well-known optimization techniques such as GA, PSO, DE, and ACO, etc. Moreover, in certain modulation index ranges, it provides faster convergence and accurate results which have been demonstrated in the paper. The computational results have been verified with the experimental result on the prototype developed in the laboratory. The field programming gate arrays (FPGA) based controller is used to implement the proposed technique. The hardware results have been found in close agreement with the computed results.

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1. Introduction

Voltage source inverters (VSI) are extensively used in many industrial applications such as active filters, variable speed drives, solar PV systems, wind energy, HVAC and HVDC transmission, electrical vehicles, etc. Earlier, only two-level and three-phase VSI configurations were mostly used (Levi et al., 2007; Chen and Zhao, 2016). But since the power processing requirements of power converters increased, the development of alternate topologies such as multilevel voltage source inverter with limited voltage and current ratings of the semiconductor devices has great attention in recent times (Wu and Narimani, 2017). The other advantages of multilevel inverters are low total harmonics distortion, low $\frac{dv}{dt}$ and low electromagnetic interferences(EMI). Various multilevel inverter topologies and its modulation and control schemes of multilevel inverters have been proposed in the literature (Colak et al., 2011; Gupta et al., 2015). The important topologies includes neutral point clamped (NPC), cascaded H-bridge (CHB), flying capacitor (FC), modular multilevel converter (MMC) and active neutral point clamped converters (ANPC) (Wu and Narimani, 2017). Several new topologies also have been proposed in recent year (Eguchi et al., 2020; Gupta et al., 2015). The promising topologies are Cascaded Half-Bridge based Multilevel DC Link (MLDCL) Inverter, T-type inverter, switched series/parallel sources (SSPS) based MLI, series connected switched sources (SCSS) based MLI, cascaded bipolar switched cells (CBSC) based MLI, multilevel module (MLM) based MLI, reversing voltage (RV) topology, two-switch enabled level-generation (2SELG) based MLI and packed E-cell topologies (Venkataramanaiah et al., 2017). These topologies are created while considering the low switching device counts, maximum possible number of levels, application oriented etc (Gupta and Bhatnagar, 2017). A detailed comparative analysis of popularly used multilevel inverter topologies is shown in Table 1. The number of devices are given for one leg of the inverter and 'n' represents the number of levels of the output phase voltage and 'V_{dc}' represents the dc-link voltage. In an NPC, more power diodes are used whereas, in an ANPC more number of active switches are used. Each topology have its own advantages and disadvantages and selection of any topology is application dependent (Kouro et al., 2010).

Power quality improvement in the output of voltage source inverter is desired for optimum performance in many applications

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https://doi.org/10.1016/j.egyr.2022.01.122
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