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RESEARCH ARTICLE-ELECTRICAL ENGINEERING

# Harmonic Minimization in a Reduced Switch Count Multilevel Inverter at Low Switching Frequency for PV Integration

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**Abstract**
Reduced-switch-count (RSC) multilevel inverters (MLIs) are attractive for photovoltaic (PV) power conversion, lowering device count, cost, and control complexity while retaining multilevel power-quality benefits. This paper proposes a reconfigurable RSC-MLI topology using only 12 switches and four DC sources, generating either 21 levels (source ratio 1:2:3:4) or 31 levels (binary ratio 1:2:4:8), suited for PV arrays interfaced through individual MPPT-controlled DC–DC converters. To compute switching angles for selective harmonic minimization under low-switching-frequency PWM, the nonlinear transcendental equations are reformulated into vector–matrix form and solved using an improved Jacobian-based iterative update shown analytically to converge quadratically. Compared with Newton–Raphson, the method reduces average iterations from 35 to 20, computation time from 12.5 to 5.2 ms, and improves solving success rate from 91.4 to 100%. The topology is validated on a TMS320F28335 DSP-based prototype: experimental output voltage THD is 5.9% (21-level) and 4.2% (31-level), with load current THD improving from 2.5 to 1.9%, closely matching simulation results. The inverter maintains output quality and harmonic performance under reduced PV irradiance (1000–800 W/m$^2$), temperature variation, and uniform DC-source fluctuations, confirming its robustness for grid-connected and standalone PV applications.

**Keywords** Reduced-switch-count multilevel inverter · Switching angles · Selective harmonic minimization · Low switching frequency · Power quality · Photovoltaic array

## 1 Introduction

Multilevel inverter (MLI) topologies play an important role in DC–AC power conversion [1–3]. Due to high industrial demand and improved performance, MLIs are highly beneficial for applications such as fuel cells, photovoltaic arrays, electric vehicles and so on. In grid-connected photovoltaic (PV) systems, multilevel inverters are extensively employed to interface renewable energy sources with the utility grid while ensuring high-quality power injection and compliance with grid codes [4, 5]. Power quality is improved using MLIs due to the staircase nature of the output voltage waveform, thereby reducing distortion [6]. The main benefits of MLIs include lower electromagnetic interference (EMI), lower stress on switches, lower dv/dt, lower di/dt and lower total harmonic distortion (THD) [7]. The presence of harmonics in the voltage generated by MLIs is a crucial metric for evaluating performance, as high THD levels lead to losses, device failures, and overheating [8]. These power quality characteristics are particularly important in PV-based power conversion systems, where strict limits on harmonic injection and voltage distortion are imposed by grid interconnection standards. These MLIs require a higher switch count to generate a larger number of levels. Additional gate driver circuits, isolation circuits, and the corresponding heat sinks and protection requirements are required as the number of switches increases [9]. As the number of voltage levels increases,

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