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Optimization of Triac Phase Control for Energy-Efficient Lighting and Loads

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Abstract

Triac-phase controlled AC power systems cause waveform distortion, harmonic pollution, and operation problems in electrical networks. In this research, the impact of clipped sine waves on power quality, equipment performance, and lighting systems is studied through experimental and simulation-based investigation. Results show that triac dimming produces high harmonic distortion (THD >30%), lowers power factor to 0.6 at 90° phase cut, and causes flicker in LED systems (flicker index >0.15), which goes against IEEE PAR1789 standards. Electromagnetic interference (EMI) from triac switching is 10–15 dBμV above CISPR 11 limits, interfering with IoT devices. While resistive loads like incandescent lamps are stable, non-dimmable LEDs and induction motors experience premature failure through inrush currents and torque ripple. The article demands the implementation of harmonic filters, power factor correction (PFC), and flicker mitigation methods to adhere to IEC 61000-3-2 and WELL Building Standards standards. Outcomes contribute to research in optimizing dimmer design towards energy efficiency and load compatibility for domestic and industrial applications.