

System-level Assessment for Power Quality Impact on Household Electronic Devices

Most household equipment depends on power electronics to convert power into form and amplitude for its operation. With high penetration of power electronics, loads, sources, energy storage, and distribution, apparatus are interfaced through a power converter. In the residential distribution grid, household electronic devices share a point of common coupling (PCC) at the house's service panel as shown in Fig 1. LED lamps, being superior alternatives to fluorescent lamps, are often used in conjunction with residential dimmers for additional energy savings. The impact a market-dominant TRIAC-based dimmer can have on these power converters due to high current transient and voltage is studied.

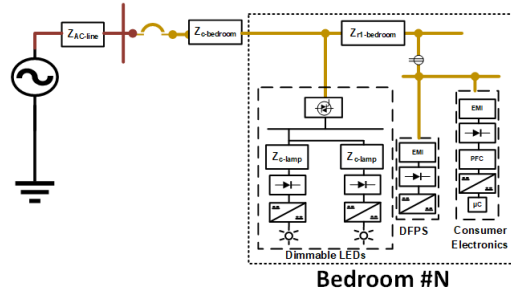


Fig. 1. One-line diagram for residential distribution grid

Fig. 2 (left image) illustrates a circuit schematic for an equivalent model of a boost PFC adapter connected to PCC with a dimmer and multiple LED lamps. The PFC adapter is a conventional PFC converter with an electromagnetic interference (EMI) filter consisting of common mode (CM) and differential mode (DM) inductors with a C_x capacitor. Downstream from the EMI filter, the adapter consists of a passive rectifier, π -filter, and boost converter. Fig. 2 (right image) shows the detailed waveform of voltage and current transient in the PFC adapter. Under TRIAC turn-on instant, the line current of LED lamps creates a current transient. At the same instant, the line current for the PFC adapter notices a current glitch. The current glitch magnitude depends on the AC line impedance and the input impedance of the PFC adapter. Due to the current glitch in the PFC adapter during the dimmer turn-on instant, the glitch is filtered out by the EMI filter and the π -filter of the PFC adapter. Due to the filtering process, the current glitch transients in the PFC adapter create mid-frequency oscillations that fall under the audible frequency range.

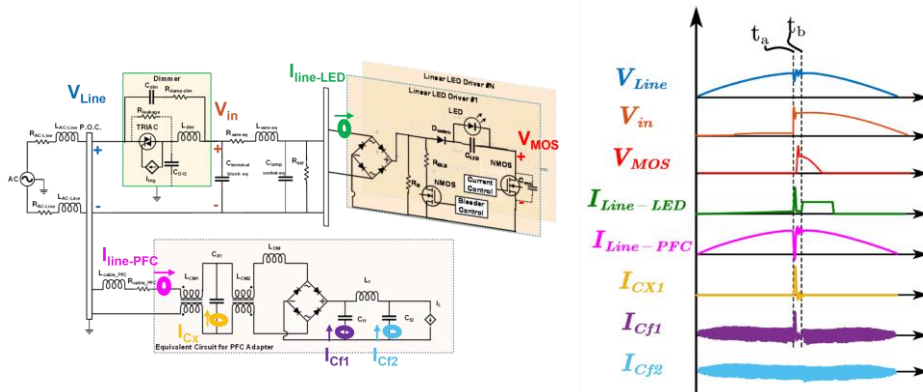


Fig. 2. Power quality degradation due to dimmable LED lamps impacting PFC adapter

Thus, dimmer-induced effects threaten the operation of other sensitive electronics connected at the PCC. The impact on key power quality indicators such as line voltage distortion and dimmer current transient during TRIAC turn-on instant can be magnified with an increased TRIAC firing angle, i.e., dimmed LED output and with an increase in the number of LED lamps. Also, the role of line impedance becomes critical as it represents the medium by which crosstalk leads to deterioration in voltage quality in the electrical system.