

Abstract

Unmitigated hazardous series arcing in low voltage electrical distribution networks may result in serious damage and lead to electrical fire in safety critical places like transportation systems, aviation systems, hospitals as well as common residential and commercial establishments. Loose electrical connections and frayed conductors are typical root conditions that lead to series arcing. Such events are immune to the existing conventional over-current protection devices due to their typical characteristics. The research work presented in this thesis is aimed at addressing the susceptibility of the low voltage (230 V, 50 Hz) distribution network towards series arcing.

In this research, the suitability of electromagnetic radiation (EMR) over current as the reliable choice of input signal for the development of arc detection algorithms is presented. Two detection algorithms based on analyzing the EMR signal in (i) spectral domain using log spectral distance and (ii) time-frequency domain using wavelet packet decomposition as metrics are developed in the thesis. Both the detection algorithms have been successfully adapted into online platforms. Next, the design and realization of a low-power, low-cost embedded platform-based real-time series arc detection device is reported. The spectral distance-based arc detection method is adapted for deployment in a micro-controller unit (MCU) (STM32F429 Discovery) board. Appropriate signal conditioning circuit is designed for interfacing the EMR input data and the MCU.

Arc fault model plays a vital role in analyzing the phenomenon of arcing, especially under various electrical scenarios that may otherwise be difficult to contrive. Reliable arc fault models can accelerate the development and validation cycles of arc detection algorithms/systems under enhanced safety and reduced cost. Addressing this research issue in the present thesis, a series arc model and its real-time implementation is reported. The model is based on representing the stochastic nature of low voltage series arc signatures with appropriate probability distribution functions and functionally connecting the respective parameters with supply voltage and load current. The detection algorithms, the embedded device, and the arc model, all have been validated with data generated from a laboratory setup involving arcing, normal, and arc-mimicking conditions.

Keywords: Arc detection, arc model, detection algorithm, electrical fault detection, electrical safety, electromagnetic radiation, embedded systems, probability density function, random variables, real-time systems, series arcing, spectral analysis, stochastic approximation, wavelet packets.