Preface

The basic principle of protective relaying of power systems has not changed for more than half a century. Almost all power system protective relaying algorithms are dominated by integral transforms such as the Fourier transform and the wavelet transform. The integral transform can only provide an average attribute of the signals or their components. The accuracy of the attribute extraction is significantly sacrificed by the assumption of periodicity of the signals if the integral transform is applied to transient signals. It is also well known that the signals are liable to be contaminated by noise in the form of exponentially decaying DC offsets, high frequency transients, harmonic distortion, errors caused by non-linearity in the response of the sensors, and unwanted behaviour of power systems. This contamination is often provoked by fault conditions, just at the time when the protection relay is required to respond and trip the circuit breaker to limit damage caused by the fault.

On the other hand, as we know, in most protection relays, complex computation has to be undertaken within a sampling interval, no matter how small the interval, to calculate the coefficients relevant to the attributes of the signals by using the integral transform based on a window of samples, and to calculate the relaying algorithms, which are derived to represent the relationship between these coefficients and power system faults. If fast transients and high-order harmonics are to be addressed, extra computing power and facilities are required. Therefore, it can be seen that the current power system relaying algorithms suffer from many problems including accuracy, fast responses, noise, disturbance rejections and reliability.

To tackle the problems of distorted waveforms, disturbances and transient components of fault voltages and currents, identification of the shapes of complex waveforms is ideally required instead of the analysis of periodic characteristics, which is undertaken by the currently used integral transform to obtain the knowledge of distorted signals indirectly. However, there is currently no generic methodology available for designing a protection relay that is able to detect the shapes of signals, in particular for protective relaying purposes.

This book introduces mathematical morphology (MM) for the design and operation of power system relays. MM has been designated as a new branch of mathematics, which is totally different from the integral transform-based methods in basic principles, algorithmic operations and approach. When used for the extraction of waveform components, MM has the following merits in comparison with the integral transform methods: (1) The morphological operators have fast and simple calculations without using multiplication and division operations. (2) It is applicable to non-periodic transient signals and not restricted to periodic signals. (3) MM uses a much smaller sampling window for real-time signal processing, as it does not require the information of the full signal components. (4) It is able to accurately and reliably extract the signal components without causing any distortion, as it is a time-domain signal processing method that does not perform any integral transforms.

We wrote this book in the belief that MM would open an opportunity to develop more accurate, reliable and faster protective relaying algorithms, leading to a new generation of power system protection relays. Apart from being an introduction to basic and advanced MM operators, presented with their pseudo codes, this book presents a number of MM-based methods developed for power system protection relays. We hope that this book will be useful for those postgraduates, academic researchers and engineers working in the area of the design and development of power system protection relays.

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