



# Overcurrent Protection for Electric Utility Systems

An Online Continuing Education Course for Engineers

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# Overcurrent Protection for Electric Utility Systems

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## Introduction

This course is an overview of how sectionalizing and protection studies are performed on electric distribution systems. It is not intended to provide a complete and exhaustive discussion of the subject, but rather to present the reader with helpful information and examples that will typically be encountered.

Within the arena of sectionalizing, there are many aspects of the subject that are established, quantifiable, and part of national standards. Included in this body of information are specific time-current characteristics of fuses and relays, the methods of calculations for available short-circuit current, and the standard damage points for distribution transformers. There are also many aspects of sectionalizing that are more subjective, debatable, and influenced by experience. These include “fuse save” versus “fuse blow,” coordination margins, and transformer protection practices. This reflects the idea that system protection is partly science and partly art.



This course concentrates on the “science” side of the subject and offers some well established practices and conventions on the “art” side. In the end, it is the responsibility of a utility’s protection engineer to recognize the specific needs and goals of the utility and apply the principles herein to the available equipment and technology to accomplish the best combination of reliability and economics possible.

Arc Flash energy available on a distribution system will be affected by system protective device settings. Although it is beyond the scope of this course to address this issue, the protection engineer is encouraged to research and understand the relationship between system settings and arc flash energy.

# Chapter 1

## Sectionalizing Philosophy

At a high level, sectionalizing is about compromises and creating the best combination of methods and practices that suits the individual utility. Goals and issues must be considered and evaluated and then implemented.

Questions that must be considered include the following:

- Which is more of a problem, blinks or longer outages?
- How high can (or should) protective devices be set?
- Are equipment maintenance cycles adequate?
- Do right-of-way cycles affect the protection plans?
- What weather patterns affect the service area?

The goal of all coordination philosophies is improved system reliability.

Inherently, the installation of any coordination device sacrifices the electric service to the loads and customers down line for the greater good of maintaining service to the rest of the customers. The device may protect major or critical loads by dropping long exposures to noncritical loads during fault conditions. But one must remember that every sectionalizing device sets a priority of service because its operation stops electric service, even temporarily, to the down line customers in favor of the rest of the circuit customers.

The protection engineer must face a compromise: Higher settings for protective devices typically will improve reliability on a distribution system by reducing the number of nuisance operations while allowing for more down line devices to be applied. On the other hand, lower settings for protective devices can improve the security of the system by clearing higher-impedance faults (at the expense of increased operations).

No single approach is right for all systems and, many times, not even for all portions of one system. Urban and rural service areas have different characteristics and different approaches may be appropriate. This course suggests an approach for determining settings for typical environments. It is important to understand the methodology and what can be achieved (as well as what cannot be achieved) rather than to use rote settings or values.

## Fault Types

Faults can generally be categorized as temporary or permanent. It is easy to agree on one thing in system protection: that permanent faults need to be disconnected or they will disconnect themselves through destruction of the system. Studies have shown that a majority of faults are temporary in nature. Historically, utilities have used devices to clear temporary faults and restore service without manual intervention. These same devices also clear permanent faults but require manual intervention to restore service afterward.

The application of these devices depends on the type of fault, the location of the fault, and how to set them depends on the fault current, the fault duration, and the fault type. A short circuit draws fault current depending on the fault impedance.

## Zones of Protection

In developing a section of a distribution system, the fault currents must be calculated. The *Maximum fault current* is the maximum current that can be drawn from the system. Devices have adequate capabilities and ratings to handle the maximum fault current. The *Minimum fault current* is the minimum current that can be drawn from the system. Devices which they may be exposed to must be able to handle the minimum fault current. Determining the minimum fault current is a function of the fault impedance for a particular device. Certain assumptions must be made when calculating the minimum fault current. It can be below load levels. Utilities have used several methods to calculate the minimum fault current in distribution systems.

- Assuming some fault impedance ( $Z_f$ ) level.
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Many utilities have used the fault impedance method successfully, and this method will be described in this course. The question that has always been considered is “What fault impedance should be used?” The recommended value is often in the range of 30 to 40 ohms for overhead lines and 10 to 20 ohms for underground lines.

From an engineering perspective, any ground fault resistance used in selecting minimum ground trip levels is a “design value” selected for calculation purposes only and should not be confused with the ground fault resistance that might occur. The values of 30 and 40 ohms have been used for many years on systems. The actual value used should be determined by the utility’s engineer. Such a practice of selecting a method that allows for the possible detection of low-level ground

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