Protection Coordination

Contents

1. Introduction

The purpose of the electrical protection coordination study is to ascertain the circuit breaker and protection relay settings.
Finding the best balance between selectivity and protection is the main objective. Determining the fault clearance time and coordinating upstream electrical protection equipment are two key elements of the study. Proper coordination and disruption clearing times can help reduce damage to electrical equipment and protect operators from harm. Protection coordination analysis studies is carried out after completing a Load flow and short circuit study.

1.1. Why Protection Coordination Study?

Electrical systems usually use fuses and circuit breakers to protect electrical equipment such as cables, transformers, motors, and other components. It is advised that any equipment malfunctions, which are typically caused by short circuits, should only impact the area of the system in question.
Let's say an electrical load in a plant experiences a short circuit fault that is a bit far from the main distribution panel. However, this outage tripped the main breaker, resulting in a blackout instead of the circuit breaker closest to the fault point which should trip.
This is the case that often occurs in electrical distribution systems with protective equipment that are not well designed and coordinated. This is where the study of protection coordination in electrical system is important.
Facilities with the correct protection coordination scheme can save money in reducing the effects of blackouts.

2. Benefits

System protection coordination studies are crucial in power system networks for several reasons:

- **Equipment Protection:**

  - Proper coordination ensures that protective devices (such as relays, fuses, and circuit breakers) operate in a coordinated manner during faults.
  - If a fault occurs, the nearest protective device should operate to isolate the faulted section while minimizing the impact on the rest of the system.
  - Without coordination, incorrect operation or delays can lead to equipment damage, extended outages, and safety hazards.

- **Reliability and Continuity:**

- Coordinated protection minimizes the extent of outages by isolating only the affected portion of the network.
- This improves overall system reliability and continuity of service for customers.

➢ **Selective Tripping:**

- Selectivity ensures that only the necessary protective device operates during a fault.
- For example, during a fault on a distribution feeder, only the nearest feeder breaker should trip, not the entire substation or network.

➢ **Safety:**

- Proper coordination prevents dangerous situations where downstream devices are exposed to excessive fault currents.
- It reduces the risk of electrical hazards for maintenance personnel and the public.

➢ **Economic Impact:**

- Coordinated protection reduces downtime, minimizing financial losses due to outages.
- It also prevents unnecessary replacement costs for damaged equipment.

3. Objectives of Protection Coordination Study

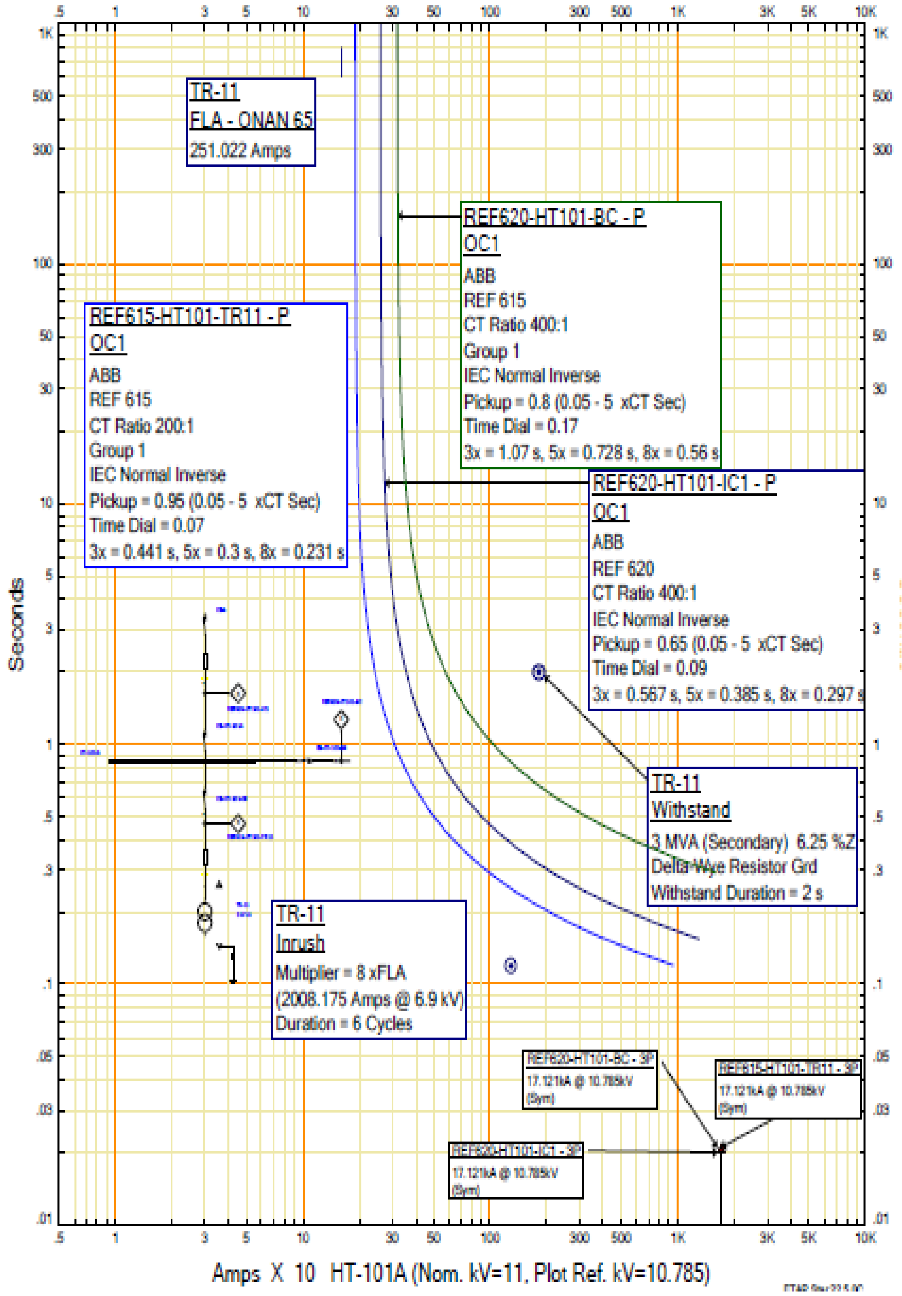
The objective of the protection coordination study is to verify that all protective equipment in the system such as relays, breakers, fuses, etc., are properly coordinated and are sized according to the protected equipment.

The benefits of a protective equipment coordination study include:

- Improved system and facility reliability
- Reduces the cost impact of a disruption.
- Improved equipment protection
- Increased operating efficiency.
- Assist in operations and help prevent unnecessary downtime.
- Prevent damage by identifying underrated equipment.
- Prevent breakdown by identifying overloaded equipment.

4. Time-current coordination

In a properly coordinated system, protective equipment is selected and adjusted to minimize the impact of equipment interference in a system. A coordination study analyzes the characteristic curves of the fuse and breaker and compares them to each other on a log-plot like the one shown in the following figure. Any areas of miscoordination will be visible with overlapping curves from various devices.



Time-current coordination (also known as **selective coordination**) ensures that protective devices, such as fuses and circuit breakers, operate in a coordinated manner during faults. The goal is to isolate the faulted section while minimizing the impact on unaffected parts of the system. Here's how it's achieved:

1. **Time-Current Curves:**
   - Each protective device has a time-current curve that represents its response time for different levels of fault current.
   - The x-axis represents current (usually in multiples of the device's rated current), and the y-axis represents time (usually in seconds).
   - The curve shows how quickly the device operates as fault current increases.

2. **Coordination Intervals:**
   - Devices are coordinated by setting specific time intervals between their curves.
   - The downstream device (closer to the load) should operate faster than the upstream device (closer to the source).
   - In some cases, if full coordination is not possible due to equipment's setting range constraints, in that case partial coordination can be achieved.

3. **Overlapping Curves:**
   - To achieve coordination, the curves of adjacent devices should overlap.
   - The overlap ensures that the downstream device operates only if the fault persists beyond the upstream device's clearing time.
   - The degree of overlap depends on the system's requirements (e.g., critical vs. non-critical loads).

4. **Adjusting Settings:**
   - Protective relays and circuit breakers have adjustable settings (e.g., pickup current, time delay).
   - Power System Engineer configure these settings based on system characteristics, load types, and fault current levels.
   - Fine-tuning ensures proper coordination.

5. Study Steps for Protection Equipment Coordination

The protection coordination study consists of the following steps:

- Data collection – In addition to the data collected for short circuit studies, additional information on the settings and current ratings of all protective devices is required.
- Manufacturer data – Each protective device has unique response characteristics, documented on the manufacturer's "time-moment curve" required for the study.
- Load flow & Short circuit study
- Computer analysis – Although protection coordination studies can be done by hand, it is much easier to use software such as ETAP, EasyPower, SKM etc.
- Software Protection coordination module allows the Engineer to determine the optimal settings that will provide the best protection for the system. In some cases, coordination between two devices is not possible. Engineering assessments are then used to determine the most appropriate arrangement that will minimize equipment damage.
- Results tab – Settings and ratings of each protective device (circuit breaker, fuse, motor controller, etc.) as determined by the analysis, are put in the table for comparison with the setting and current field values.
- Final report – A detailed report describing the scope of the study, all assumptions, data origins (including current-time curve), tabulated results, and recommendations for corrective action are published at the end of the study.

6. Standards

Standard / Codes	Title / Description
IEC 60909-0-2016	Short-circuit currents in three-phase A.C. Systems
IEC 62271-100-2021	High-voltage switchgear and control gear-Part 100 Alternating current circuit-breakers
IEC 61439-2-2020	Low-voltage switchgear and control gear assemblies
IEEE 242, 446	IEEE Guide for Practice for Protection & Coordination of Industrial & Commercial Power Systems