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Protection and Operation Analysis on the Overhead Transmission Line

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Abstract
Overhead transmission lines play a pivotal role in the efficient distribution of electrical energy across vast geographical areas. However, these infrastructures face numerous challenges, including environmental factors, operational constraints and the constant threat of faults. This paper explores the critical aspects of protection and operation on overhead transmission lines, aiming to enhance their reliability, efficiency and safety. Through a comprehensive analysis of existing methodologies, technological advancements, and case studies, this research proposes innovative strategies to mitigate risks, optimize operations, and improve fault detection and restoration processes. This paper investigates recent advancements in protection and operational techniques, considering factors such as reliability, efficiency, sustainability, and resilience. Through a comprehensive analysis of current practices, emerging technologies, and regulatory frameworks, this paper aims to provide insights and recommendations for enhancing the performance and reliability of overhead transmission lines.
Key Words: *Protection, Transmission Line, Overcurrent relay and DTOC relay*

I. Introduction

One-fifth of the global final energy consumption is in the form of electricity. Electricity is consumed primarily by industry, residential, commercial and public services. Unlike other major energy forms such as coal, oil, and natural gas, electricity cannot be stored on a large scale. Therefore, the production and consumption of electricity must be continuously balanced. The power system today is one of the largest and most complex human construction.

The role of the power grid is to connect energy generation with the energy consumption [1-3]. It means transmission lines carry electric energy from one point to another point in an electric power system. They can carry alternating current or direct current or a system can be a combination of both. Also, electric current can be carried out by either overhead or underground lines [4, 5]. The main characteristics that distinguish transmission lines from distribution lines are that they are operated at relatively high voltages, they transmit large quantities of power and they transmit power over large distance [6-8].

An overcurrent protection relay operates based on the principle of detecting excessive current flowing through an electrical circuit. The relay’s main function is to monitor the current levels in the circuit and, if the current exceeds a predefined threshold (setpoint), the relay activates a mechanism to interrupt the circuit, protecting the electrical system from damage [9, 10]. The time gap between the primary and remote backup protection devices is known as the coordination time interval. It is the interval between the operating times of the backup relaying and the interval between the clearing of the fault by circuit breakers during the primary relaying [11, 12]. A number of variables, such as current transformer error, the direct current offset component of the fault current, and relay over travel, make it difficult to determine the exact relay operating timings. To consider these aspects in the majority of real applications, typical coordination time coordination intervals between 0.2 and 0.5 s are chosen. Inappropriate over-current relay parameter adjustments could result in catastrophe. It is crucial to verify the settings of power protection equipment and to ensure its operation under various fault scenarios to prevent negative things from happening. In this small work, MATLAB/Simulink is used to model the over-current relay. The main purpose of this work is to analyze the applications of the definite time overcurrent on various types of faults by using MATLAB/Simulink.

II. Literature Review

An overcurrent relay protects against over-currents as its name implies. This relay compares the measured values to predetermined values using current inputs from a CT. The logical representation of an overcurrent relay is shown in Fig. 1.

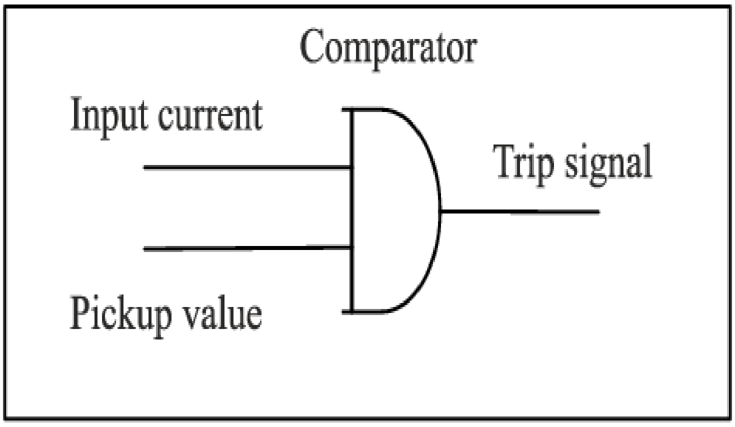

Fig. 1. Logical representation of over-current relay [13]

The breaker will disconnect automatically to protect equipment from damage when it receives a signal trip. This will happen when the input current value is higher than the preset value. Fault pickup is the term used to describe the situation when a relay senses a fault. In the case of instantaneous overcurrent relays, the relay can send a trip signal right before sending a trip signal. The relay computes this time delay, also known as the operation time of the relay, based on the protection algorithm built into the microprocessor as shown in Fig. 2.

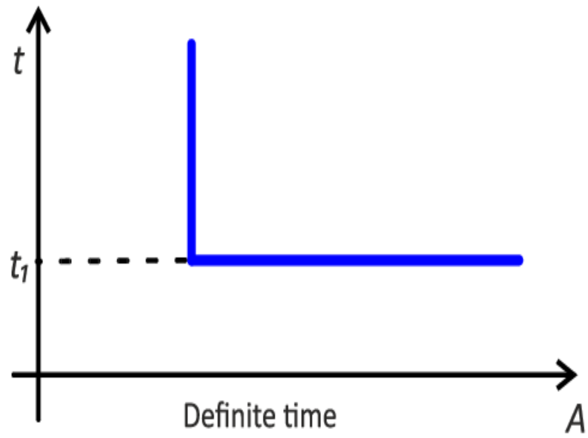

Fig. 2. Definite time over-current relay

The structure of a definite time overcurrent relay is provided in below figure. In this type, two conditions must be met for operation(tripping): the current must exceed the set value, and the fault must persist for a duration equal to the relay's time setting. When a distance relay is used as the primary protection for a transmission line, this over-current relay serves as backup protection. After a predetermined amount of time has passed, the over-current relay operates with a time delay that is just slightly longer than the combined period that the distance relay operates normally, and the breaker operates.

Two requirements must be met for this sort of overcurrent relay to operate or trip. First, the current must be greater than the setting value and second, the fault must persist for at least as long as the relay's setting time. Regarding its use, the definite time overcurrent relay can function in different conditions in electrical systems. It can serve as a backup protection system for transmission lines with time delays that have distance relays. Additionally, it can serve as a backup protection system for a power transformer's differential relay with a time delay. The primary defense, in addition to serving as a backup, is provided by incoming feeders and bus couplers with customizable time delay settings.

III. Method of Coordination of DTOC Relay Simulation

Relay coordination plays a critical role in maintaining the integrity and stability of power systems. It ensures that faults are accurately detected and isolated while minimizing disruption to the overall system operation. Through careful design, analysis, and simulation, engineers can achieve effective coordination of protective relays, allowing for a safe and efficient operation of the power system. Given below figure depicts the application of DTOC relaying without fault coordination modeling, which has been implemented using MATKAB/Simulink as shown in Fig. 3. The purpose of this modeling is to analyze the behavior and performance of the relay system under different fault scenarios. By studying the relay operation and coordination in a simulated environment, engineers can optimize and fine-tune the relay settings to achieve the desired level of reliability and selectivity as shown in Fig. 4.

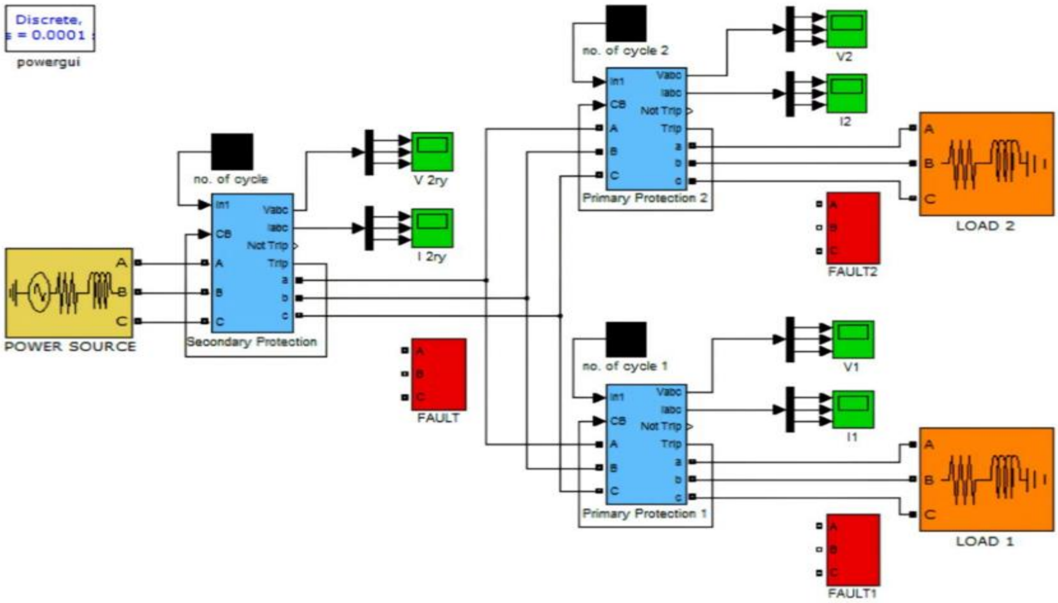

Fig. 3. DTOC relaying without faults coordination modelling in MATLAB

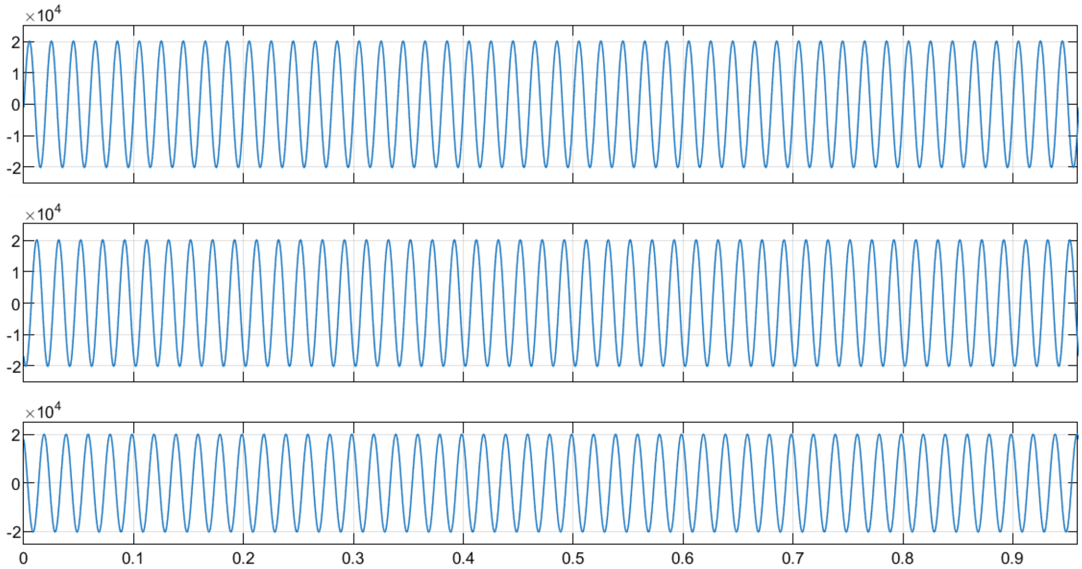

Fig. 4. DTOC relay without fault

3.1 DTOC relaying setting

In power systems, the DTOC relay is the main defense mechanism for power systems. The relay begins to operate for DTOC characteristics after an intended time delay (operation time). Current must be greater than the setting value for the relay to operate (trip), and the fault must be ongoing for at least the relay's setting in time. Modern relays may have multiple protection stages, each of which has its current and timing settings. The operating time is constant for operation of DTOC relay. The amount of current above the pick-up value has no bearing on how well it operates. It contains pick-up and time dial settings, an intended time delay system that lets you choose the required time delay, and it's simple to coordinate. It offers constant travel time irrespective of fault location and in-feed variation.

Time grading/discrimination of action must be properly coordinated with the operational DTOCs relays. The relay sub-system must function well first since it is certain that the other systems are in good condition. Symmetric ground faults occurred simultaneously throughout the power system, but temporal discrimination allowed the relay closet to the load side to function. To ensure that the right time lag is operational time, the time constant is altered. Since the subsystem has a shorter time lag value, it will trip out first.

3.2 Three-phase fault occurring at load 2

As for the three-phase fault occurring at load 2, the current and voltage were in normal state condition until the interruption had occurred at load 2 at time 0.6 s until 0.675s where the 3-phase fault happens. It is similar to the fault occurring at load 1 where the fault is between the primary protection 2 and load 2.

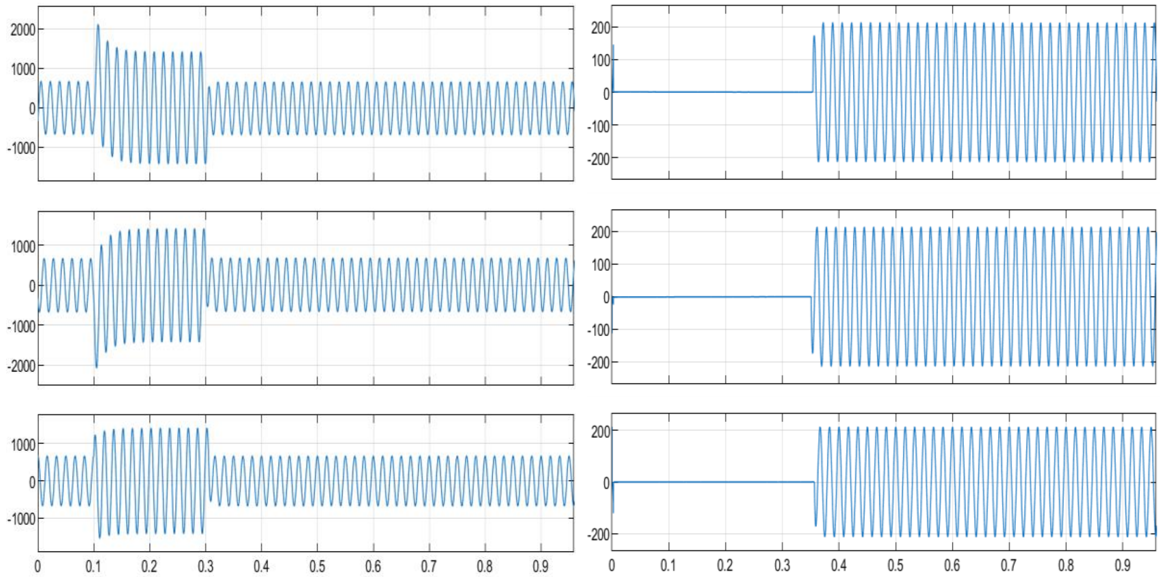

Fig. 5. Relay steady state conditions with different time-periods

Fig 5 shows that there is a steady state conditions at time 0.6s until 0.675s, which means that there is no current supplied to the load 1 when the fault occur at load 2. As for the voltage, the results for the voltage at load 1. The current magnitudes were increased by about 4v at a time 0.6s due to the short circuit and it can damage the load. To prevent this, the primary protection 2 (relay and circuit breaker) will disconnect the circuit for load 2 when it receives the signal during the fault. The result shows that the steady state condition started from 0.6s which means there is no voltage supplied when the circuit is disconnected.

IV. CONCLUSION

In real conditions, a few factors must be considered for setting the relay, such as time multiplier settings, pickup value, characteristic curves. to ensure the safety and fast operation of the over-current relay. If not, the relay cannot detect the faulty conditions and will not trip, thus, cannot send a false tripping command. By using MATLAB/Simulink software, it can simulate any position of fault occurrence without any obstacle and the result can be seen through the scope. From the output, we can design the suitable operation or protection than can be provided to a certain situation. From several types of overcurrent relay, definite time overcurrent relay usually acts as back up protection relay whenever the main protection fails to execute the fault completely. However, in a certain time, this definite time overcurrent relay act as the main protection to outgoing feeders and bus couplers with adjustable time delay setting. Therefore, it can be concluded that all the objectives of this mini work have been achieved. As a contribution, this DTOC relay is a reliable component that ensures the safety of equipment. This is because it can react or used as back-up protection if the distance relay (primary protection) cannot perform well as a protection tool.

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