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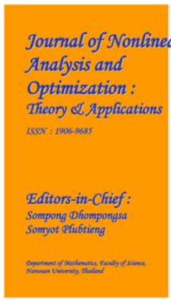


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# ADVANCED METHOD FOR CONTROLLING AND PROTECTING POWER SYSTEMS

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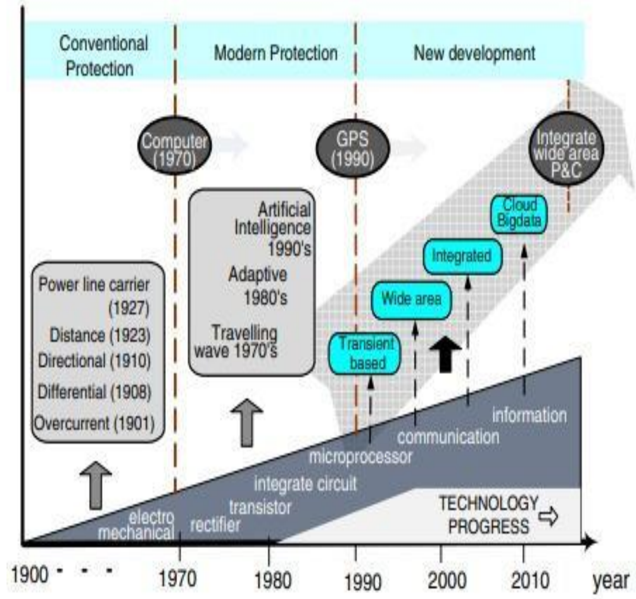
**ABSTRACT:** Substations and wide area protection and control systems can now interact in real time thanks to the innovative technology known as accompany large area communication. The inadequacy of the existing protection and control system in managing this real-time data has been acknowledged. To investigate the future evolution of protection and control systems, this study first examines the historical progression of power system protection, with an emphasis on recent advances in integrated and wide-area safeguards. An novel technique for managing and protecting electricity systems is offered. The concept of integrated broad area protection and control is then introduced, demonstrating how a hierarchical protection and control system protects and regulates regional or wide area power substations and plants, as well as the power networks that connect them. The system consists mostly of three layers: local, substation/plant, and big area/regional. To develop an optimal coordination mechanism between each level, detailed explanations of the integrated functions at each level are provided. The suggested system's fundamental component is a real-time information platform for wide-area protection and control. It makes it easier to incorporate three lines of defense for power system safety and control, as well as the best tool for implementing cloud computing in substations and power networks.

***Keywords:*** *Relay Protection, Differential Protection, Distance Protection, Overcurrent Protection.*

## I.INTRODUCTION

It began in 1900, with the introduction of the first electromechanical overcurrent control system. The majority of protection principles utilized in protection relays were developed within the first thirty years of the twentieth century. These include differential, directional, overcurrent, and distance protections. Advancements have occurred in modern science and technology, particularly in the fields of electronics and computers. This has advanced relay technology by enhancing the components, manufacturing processes, and materials used to build the mechanical structure of relay protection devices. Major theoretical advances have occurred simultaneously in relay protection software, algorithms, and related disciplines. Advances in current technology are resulting in increased protection for electrical systems. Relay security evolved through various changes between its inception a century ago and the late 1990s. Following electromechanical approaches, microprocessors, integrated circuits, and semiconductors were developed. Digital and numeric relays, which use microprocessors, are now replacing traditional relays in all aspects of power system protection. However, key concepts linked to secure relaying remain relevant today. In the 1960s, it was proposed that a substation security system based on a centralized computer system would be helpful. The current situation is critical in the progress of power system security. Integrated protection reflects the proposal's overall concept. In this scenario, the protection package would monitor a portion of the network as well as specific facility units. Until recently, this notion was not extensively adopted because to a lack of computer hardware, software, and communication technologies. Digital approaches have allowed for significant advancements in relay technology. Microprocessors were first employed for security measures in the 1980s, which paved the way for the development of distributed processing platforms aimed at securing specific system components. The built-in security was ineffective as a backup and remained in a supporting capacity. Power system protection improved in the 1980s and 1990s, particularly with the introduction of "adaptive protection" and AI-based protection concepts. Traditionally, the first sort of protection utilized was Inverse Definite Minimum Time Overcurrent (IDMT). It signified the start of flexible security. The extensive use of computers and control theory in the 1980s emphasized the significance of this concept. This relay protection can modify its operation, function, or assigned value in response to the power system's defect situation and operation mode. Adaptive relay protection improves security efforts to ensure the safety of the power system.




Adaptive relay protection offers advantages such as increased system reliability, higher profitability, and faster system response times. It has a multitude of applications, including transformers, generators, and long-range defense systems. To properly protect the system, the communication network must provide detailed information about the system's operation and defects in a way that is adaptable to various defect states and modes of operation. During the 1990s, computer and electrical technology advanced significantly. During this time, artificial intelligence technologies including genetic and evolutionary algorithms, artificial neural networks, and other research tools were developed and used to relay protection. Artificial neural networks (ANNs) are used in a variety of applications, including fault classification, fault distance measurement, direction protection, and more. Artificial neural networks are capable of processing data, self-organizing, learning autonomously, and storing data in multiple locations at the same time. In the future, there will be a sophisticated diagnostic system powered by AI. This improves the speed and precision with which faults are identified and analyzed. The changes have resulted in increased efficiency of the protective switches. However, the application of adaptive and artificial intelligence technologies has not resulted in the development of any novel and intriguing relaying notions. The innovations have primarily focused on improving current relaying systems. In the 1990s, researchers investigated various methods for detecting defects in the frequency of non-power systems in order to enhance the speed of relay responses as the power network expanded. This measure was important to quickly repair errors and improve system stability. As a result, "transient-based protection" relays were developed, which use fault-generated transients to send waves through stacked components, thereby protecting communication networks. Scholars discovered that high-frequency fault-induced transients can be detected and recorded. This enables the development of new defense systems and approaches. High frequency transient recognition research is becoming increasingly popular. Using the global positioning system (GPS) to protect power systems is a significant leap in communication technology. Novel ideas have been proposed in this subject. The recently proposed protection relay theory can be utilized to defend large power networks. Following expansion, the concept of safeguarding a broad area based on The topic of authority has been discussed.

## II. POWER SYSTEM CONTROL AND PROTECTION INNOVATIONS

Recent advancements in power system protection, control, and broad area control have been noteworthy, particularly in the areas of wide-area and integrated protection. These breakthroughs were made recently. These advances, the outcome of newly discovered methodologies and technologies, are due to innovations in information technology and high-speed communication networks.

There have been significant advances in complete protection. As communication technologies have advanced, it has become considerably easier to transmit information over long distances. When it comes to designing power system protection systems, the broad area measuring system provides a new perspective. The concept of wide-area protection was first introduced in 1996 with the use of transient-based protection systems that relied heavily on GPS time synchronization.

This was the first time that extensive protection was used. In 1997, a summary paper was published that presented the concept of "wide area protection" methodically, with a focus on the region's management component. To prevent voltage collapse, broad area protection uses sophisticated algorithms generated from data from a variety of sources. These algorithms offer relay protection, security, and stability control. It can resolve faults quickly, reliably, and accurately, as well as examine the impact of fault system analysis on system stability. The wide area relay protection mechanism has recently been thrust to the forefront of scientific analysis as a result of the extensive dissemination of study results.

## III.INTEGRATEDPROTECTION

Advances in digital technology have resulted in the integration of several protection functions for distinct equipment components into a single protective device, achieving a certain level of integration. A numeric line protection relay can have directional and overcurrent functions as additional safeguards, with distance or current difference functions serving as the primary protection.

Recent advancements in microprocessor and communication technologies have enabled the development of novel protection concepts and schemes based on the analysis of data from various power facilities and components. These solutions have the potential to outperform protective techniques based on a specific plant or component in terms of the significant benefits they can provide. Integrated protection focuses on developing novel algorithms and concepts based on data from several measurement sites, rather than just concentrating the relay's software and hardware in a central location, as seen in centralized protection. This method is expected to significantly increase the effectiveness of protection. Research was conducted on integrated wide-area protection.

## IV.NEWTECHNIQUEANDDEVELOPMENT

A innovative concept for merging wide-area protection and control was recently proposed, building on previous accomplishments in this field. At the regional or wide-area scale, the concept's primary goal is to combine protection and control. This will strengthen the protection and control system by combining three lines of defense and online self-healing decision-making to minimize cascading tripping in large-area power networks. Comprehensive administration and protection of a large territory are implemented.

A three-level hierarchically coordinated system protects and controls regional or wide-area power substations and their accompanying power network, which is supported by a real-time synchronized wide-area communication network designed specifically for this purpose. The system's main component is the integrated wide area protection and control information platform. This platform allows for the smooth integration of protection and control operations at the regional or large area levels by receiving synchronized real-time data from the communication network.

The information platform helps to develop a cloud computing system designed specifically to perform a variety of support services for power networks and substations. The platform must have a large storage capacity for defect information and data, efficient data processing capabilities, powerful communication functions, and additional security measures in addition to the necessary relay protection elements. Scheduling networks and control devices should be able to remotely monitor and share system data, information, and resources using a computer monitoring system for substation communication.

The proposed platform can help adjust the architecture of future substation equipment to build a flexible framework for developing an interactive grid, thereby improving the power grid's security and dependability. Integration of broad-spectrum and local security monitoring Architecture features an integrated system for wide-area protection and control. An illustration of the proposed complete protection and control system for large areas or regions is provided. Significant advances have been made in power transmission and distribution networks. Examples include distributed generation, energy storage in distribution systems, series compensation in alternating current lines, and high-voltage DC lines in transmission networks. These recent advances result in features that are significantly more complex than older systems.

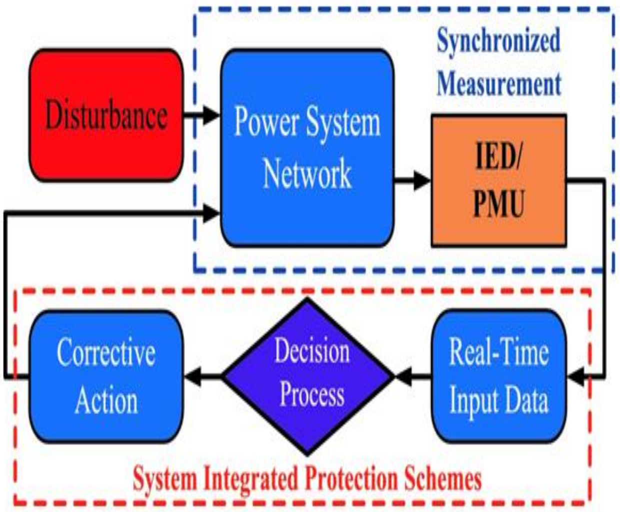
The current protection and control system could not manage the new systems, thus a new system was constructed. The system is made up of numerous devices located at several levels: intelligent devices at the local level, communication networks, information platforms, and protection systems at the regional level, and communication networks and protection systems at the substation level.

The system's key components are the high-speed wide-area communication network and the real-time synchronization information platform. The dispatching process uses a three-level architecture (national, provincial, and regional) to develop regional protection, control, and dispatching management systems. This enables the integration of power grid automation, control, and protection.

The majority of the substation's integrated secondary equipment is made up of intelligent devices that can perform multiple local functions, such as Musiquetétété, intelligent terminal, metrology measurement, PMU, and local protection.

The equipment manages real-time data sampling and information transmission to the wide area P&C and integrated substation P&C. It also accepts and executes control commands from the integrated substation protection and control system. The device can be integrated into primary power systems, providing local protection for 90% of the connected line segments. Additional functions include data storage, network analysis, and a defect recorder. It also includes a redundant configuration to ensure reliability.

Integratedsubstationprotectionandcontrolatthesubstation/plantlevelThe substation P&C system protects many components, including lines, buses, transformers, switch failure, autoreclosure, automatic bus transfer, UFLS, UVLS, overload intertripping, and substation management activities. The system uses data from the entire substation, among other things, to provide automatic control and backup protection for the substation. The old protection system's stage overcurrent protection, breaker failure protection, and dead zone protection are replaced by current differential protection, which is set up with circuit breakers.




## V.EFFICIENT REGIONAL AND OVERALL PROTECTION

The IWAPC, which was designed exclusively for safeguarding and controlling power networks, provides immediate protection. Both models support automatic Under Voltage Load Shedding (UVLS) and Under Frequency Load Shedding (UFLS), as well as frequency and voltage management, oscillation detection, and out-of-step separation, among other features. Furthermore, the IWAPC incorporates a safety P&C function for transmission cross-section. The IWAPC effectively coordinates protection and control across wide territories, resulting in considerable advances in power system protection and control. This differs from traditional methods, which segregate protection and control in both design and operation.

Infrastructure for coordinating information Substations, which are made up of a number of carefully designed electrical components, are challenging to maintain. Because of continual developments in power system automation and intelligence, the system network has expanded to accommodate the substantial amount of data used in protection and control. Interoperability of internal power system data is limited since each piece of information is collected and stored independently by various devices within different systems.

Complex communication protocols may also result in the emergence of information silos. As a result, sharing measurement data and protective control systems is strictly forbidden, limiting the assimilation of information. Meeting the evolving app needs is critical to the smart grid's security and compliance. This also increases system openness and the information platform's capacity for future important technology development.

The real-time synchronized information platform collects data from a vast region and analyzes the logical links between the data to increase defect tolerance, sensitivity, and dependability. The platform provides information on circuit breaker status as well as other static, dynamic, and transient measurements. Critical information is retrieved from the data and assigned to calculation algorithms intended for the platform's sophisticated protection and control activities on the power grid.

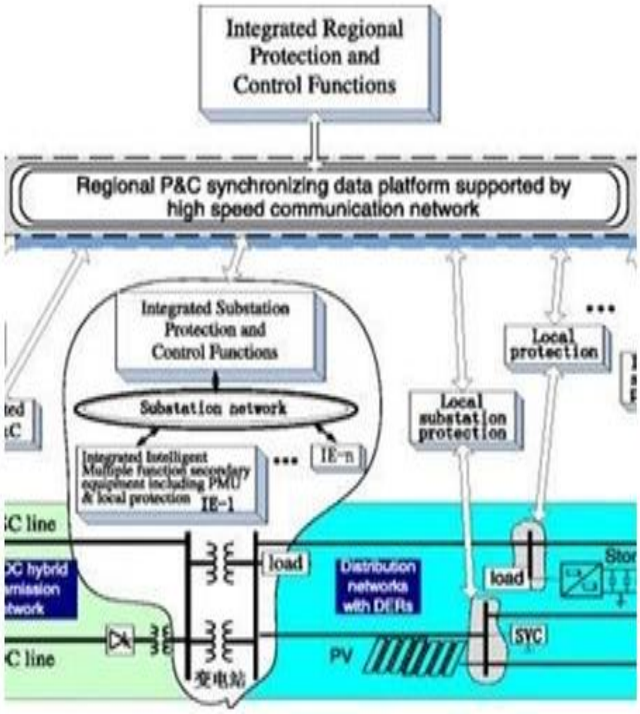
The program determines the most efficient transfer speed for several types of data sets on the platform, including slow for time synchronization, near-real-time for monitoring, real-time for control, and wide area protection, which entails sending data sets throughout the platform.Additional statistics that could be included in the information include ambient temperature, wind direction and speed, sun intensity, and transformer oil. The information in the hierarchical protection and control system is organized hierarchically, rather than centrally. The system provides fast protection and complete control over the whole power grid thanks to advanced control system improvements, smart protection procedures, and high-speed synchronized communication technologies. Advanced computing technology is used to create a synchronized information platform for wide-area protection and control, a network for data collection on operations and maintenance, a standardized interface for the terminal device, and a flexible, interactive, open, and well-organized information platform that shares resources. Advanced computing technologies are used to create a synchronized information platform with the goal of removing barriers between protection and control systems across substations, optimizing terminal data collection equipment, and establishing a distributed collaborative intelligent information platform.

## VI.WIDE AREA POWER CLOUD

A distributed cloud system is designed to perform substation and regional-level activities on the previously described information platform. These operations involve selecting fault lines, monitoring power quality, and configuring protective settings. Functions such as operation administration, life cycle management, and equipment monitoring are also improved.

Currently, a variety of secondary equipment types are deployed in each substation to perform diverse functions; the growing number of distributed energy resources with tiny capacities greatly increases the quantity of equipment. By incorporating complicated features into a well-designed distributed "cloud" system, these technologies can be implemented at significantly lower equipment costs. The information platform receives precise data from both the substation and regional clouds. The data includes static, dynamic, and transient circuit breaker states, as well as associated measurements. The platform's specialized computer algorithms retrieve and process data to perform difficult tasks such as defect detection, line identification, and harmonic content analysis.

The cloud computing platform can improve the efficiency of using cloud processing capability by reducing the burden on terminal secondary devices. Big data techniques provide tremendous processing power to the cloud computing infrastructure when needed. Software upgrades are optional for specific task processing operations, and ongoing enhancements are not required to increase the equipment's processing capabilities. The cloud system has several advantages, including the ability to share information over wide geographical areas, standardize software and algorithms, reduce equipment procurement costs, optimize substation space consumption, and streamline maintenance and operating staff demands.




## VII.CONCLUSION

This method provides a comprehensive protection and control system that combines protection and control at multiple levels (local, substation, and regional) through a hierarchical architecture. The system is supported by a high-speed synchronized communication network, a real-time protection and control information platform, as well as distribution and transmission networks. The system provides enhanced management over the entire power network as well as efficient protection by integrating cutting-edge protection approaches with the most recent advances in control technology.

This scenario provides an opportunity to merge the three lines of protection into a unified and coherent system, thereby boosting the security and dependability of the electrical grid. Based on the system information platform, a distributed power cloud system is being developed to provide a variety of sophisticated applications for integrated broad area protection and control. Because of ongoing improvements in measurement, communication, and information technology, the system has tremendous promise for future practical applications.

The proposed system should enhance protection and control operations in general. However, for the system to be useful in power system applications, its practical implementation must be cost-effective, user-friendly, and trouble-free. The authors argue that the proposed integrated approach to administration and protection at the regional level is an appealing method for achieving these objectives.

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