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starring role for relays

the future of power system protection and control

IN THE YEARS AHEAD, ELECTRICAL power system protection will enjoy fundamental, far-reaching, and fascinating changes. I would like to discuss these potential changes and their impact on the existing technology and organizations. However, to better appreciate what is waiting in the wings, a brief history of relaying would be helpful.

In 1884, the electrical engineering community responded to the challenges associated with the technical advances and problems of the burgeoning electrical industry by forming the American Institute of Electrical Engineers (AIEE). In 1963, the organization joined forces with the Institute of Radio Engineers (IRE), eventually forming what is now the Institute of Electrical and Electronics Engineers (IEEE). During its first 40 years, the committee initially concerned itself with units and standards, and then gradually expanded its scope of interest to include alternating current (ac) facilities, electric lighting, and the transmission of power. The subject of relaying or system protection was never mentioned.

In 1917, relaying was the province of the Committee on Protective Devices, which addressed protection through ad hoc groups such as the Subcommittee of Relay Protection and the Subcommittee on Definitions and Nomenclature. In 1947, all of the protection subcommittees separated from the Committee on Protective Devices, and the AIEE Power System Relay Committee (PSRC) was formed. The next 60 years were a period of intense and invaluable activity and accomplishment. Turbine generator capacity reached 1,000 MW and was going higher. AC transmission lines were energized at 500 kV and 765 kV. High voltage direct current (HVDC) lines were placed in service.

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As a natural concomitant to this system growth, protection technology kept pace. Relay expertise evolved and improved dramatically. Communication channels became an integral part of the relay system, allowing 100% line coverage, and enabled transfer tripping with their many associated applications. Distance relays became standard but introduced the concern of load as a limiting factor. The analysis of a number of widespread blackouts resulted in changes in fundamentals. Individual equipment protection gave way to system considerations. System stability, underfrequency, undervoltage, and other system phenomena became essential items to monitor and include in any overall protection plan.

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But perhaps the most dramatic change was in the relay's function, application, and ability as the technology went from electromechanical to solid state to digital. It was with this development and the acceptance of computer relays that the essential protection technology changed fundamentally and formerly unheard of protection concepts could become possible, maybe even commonplace. The immediate apparent advantage was the ability for a relay to monitor itself. Simple internal diagnostics could detect failed components and correct and alert a central office and/or remove the components from service. This feature has not been applied as rigorously as is possible, but in the coming years, we may see an increase in features of this kind. The next most dramatic use of digital relays is in the integration of protection, metering, data collection, control, and communication—functions that, in the future, will be a major feature of relays. This use has already begun, and standards such as IEC 61850 are addressing this feature. Also, this integration of functions within a substation is being addressed and is introducing station and system performance, monitoring, and analysis that are materially altering our way of approaching system operation.

A fascinating side effect of this integration of functions may be the impact it has on the organization of IEEE Power & Energy Society (PES). Existing committees will find themselves stepping on each other's scopes unless they adapt to inevitable changes in their activities and responsibilities. Remember, the responsibility of relaying was transferred from the

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Committee on Protective Devices to the PSRC. And within the PSRC, separate motor and generator protection committees were combined into the Rotating Machinery Committee, and a System Protection Committee was added. Reorganization is a natural byproduct of technological advances.

In the coming years, we should see an increase in protective relays embracing more of the system concerns. The PSRC has an ongoing worldwide survey to review the application of system integrity protective systems (SIPS) that already identifies relay remedial action schemes, such as underfrequency and undervoltage load shedding, overload mitigation, generator rejection or runback, and system separation. The response to this survey indicates that future protection concepts and practices will take advantage of the digital computer technology in unprecedented ways. SIPS are automated systems that protect the transmission grid and associated generators and loads against a wide variety of contingencies. These schemes cover an entire region, which may include multiple control centers, and can initiate corrective action or alert the system operators to take action. This ability will be greatly increased in the future, as improved digital relays, measuring units, and communication equipment become available.

The September/October 2008 issue of *IEEE Power & Energy Magazine* featured articles that addressed the application of wide-area measurement systems (WAMSs), the global positioning system (GPS), COMTRADE, and synchrophasors—all of which have been introduced to improve system protection. The WAMS, as applied to power system protection, is a synergistic combination of relays, measuring instruments control, and automation equipment. COMTRADE and synchrophasors are industry standards that have been introduced to allow digital relays of different manufacturers to exchange data. All of these features are being introduced worldwide to drastically alter the protection technology in the coming years.

For protective relaying, perhaps the most advantageous use of the WAMS is its help in adapting the specifics of a given protection scheme to actual system conditions. Digital relays have a menu of settings and control functions that can be invoked as system parameters such as load, stability, and configuration change. One feature that will be of inestimable value—in fact, it is already being employed by a few utilities—is the ability to change from a traditional configuration that allows possible unnecessary tripping ("dependability" in relaying parlance) to a design that recognizes that any additional tripping (security) will exacerbate a worsening system condition.

We are clearly entering a time when system protection will no longer be an afterthought or an unnecessary element in system performance. It is becoming an integral part of the power system technology. The ability to act in conjunction with communication, control, and monitoring equipment to maintain a secure and stable system is evidently within our grasp. The coming years will be an exciting, innovative, and challenging time. In 2000, the National Academy of Engineering voted the electric power industry as the technology most beneficial to mankind in the 20th century. In the future, exciting and demanding changes in the panoply of relaying will lead to advantages and benefits beyond even today's industry's considered judgment.