Protective Relays — Past, Present, and Future... ...a Path of Great Resistance.

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It is interesting to reflect on the history of an industry when there is a paradigm change in the making, especially when that industry has engrained roots of conservatism as a basis of its culture. Edison's dream of lighting the world using electricity spawned the largest industrial infrastructure in the world and enabled thousands of spin-off industries through the availability of cheap electric power. One of the keys to making electric power available was the development of protective devices to monitor the health of the power system equipment. This was a critical piece of the puzzle since faults on the power system required decision times much too fast for human intervention in order to protect critical components like generators, transformers, circuit breakers, and transmission lines. The ability to have a device that could directly monitor the changing voltage and current and make control decisions to maintain the stability and continuity of the system became a science unto itself.

In a very short time, demands on the power system grid increased as generators grew in size and capacity. This resulted in higher voltages to transport the power farther away from the source to serve everexpanding and more complex loads. Each evolution of the grid (longer lines, parallel lines, ring topologies, multiple generators) created new operating conditions and unknown fault scenarios. In order to limit the damage to the grid and the equipment being protected, the protective relay had to evolve. However, from a business perspective aptly described by J. Lewis Blackburn, "protective relaying is a nonprofit, nonrevenue-producing item that is not necessary in the normal operation of an electric power system...". This attitude prevailed in the past, and some contend it was the main reason protective relay evolution was slow to develop.

To see this we can observe the timeline of relay advancement compared to power system milestones from 1900 to 1970 in the list below:

1903	1st Steam Turbine Generator
1907	Plunger type overcurrent relay introduced
1913	Southern California Edison brings electricity to Los Angeles with 150 kV line
1920	Induction disk type overcurrent relay introduced
1920s	1st high-pressure steam power plants like Boston Edison's Edgar Station
1920s	1st windmills used to drive generators in the Plains states
1933	Tennessee Valley Authority established
1935	1st generator at Hoover Dam begins operation
1935	In 6 years, the REA establishes 800 co-ops and 350,000 miles of power line
	Induction cup type directional relay introduced
1942	Grand Coulee Dam completed
1950	Distance relay introduced
1951	Directional comparison relay introduced
1952	Pilot wire relay introduced
1953	AEP creates 345 kV backbone for seven-state power grid

1953 Transformer protection relay based on percentage current differential introduced

1955 All needs of Arco, Idaho powered by nuclear power plant

1956 Phase comparison relay introduced

Static bus bar protection relay introduced

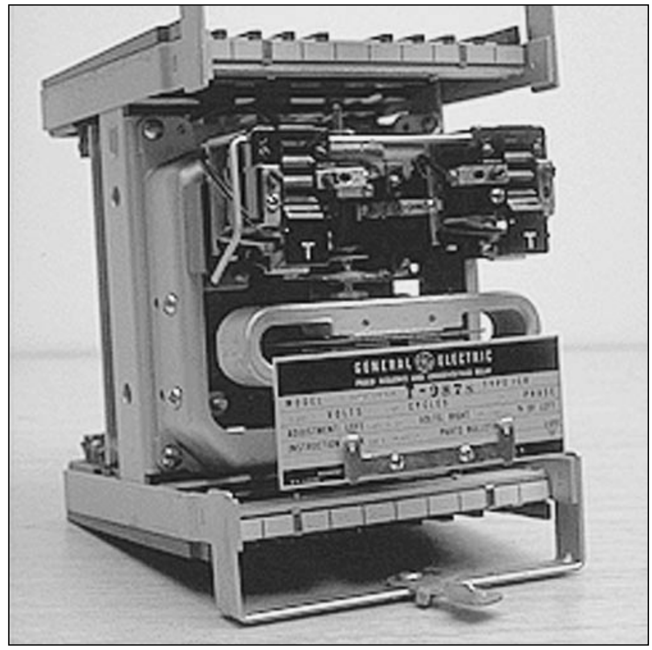
1967 750 kV transmission line developed by AEP

1969 World's first static phase comparison relay

So it is clear that the first distance relays were just being put to use by the time nuclear power plants were already in use. Up until this milestone in relaying, the overcurrent protective relay was the workhorse of the industry. No wonder that it still makes up 70 percent of the installed relay base worldwide.

Forces in the market place and new technology of the 1970's (as power systems matured) caused a significant change. The markets had become dependent on electricity; it was viewed as a basic necessity instead of a luxury. The development of the transistor…well, we already know how that story turned out, resulted in new engineering possibilities in everything. In the field of protective relaying, it brought about two key results — the ability to integrate multiple and more complex protection functions for both economic and system protection reasons, and the unfortunate reality of how a new technology must be survivable in the power system. Early adopters of static-based protective relays in the 1970s and 1980s learned this lesson the hard way despite the precautions they used to implement it. As a result, the adoption of new technologies in protective relaying was set back a decade. No sense in making something that nobody wanted to buy, and this gave electromechanical relays an extended life well into the 1990s.

Technology and persistent engineering would eventually solve these early teething problems, and that, coupled with new economic pressures during the 1990s, opened the door for the present generation of protective relays based on microprocessors. These new relays would quickly be established as the wave of the future. But in reality it was just the tip of the iceberg so to speak. Present day microprocessor-based protective relays barely resemble their early 1990s distant cousins. Most early microprocessor relays became obsolete so fast (thanks to Moore's law) that again there was concern in the industry of a repeat of the static relay scenario and a continued resurrection of electromechanical relays was a possibility, but the advantages in economics and programmability of the microprocessor kept enough positive momentum alive to sustain it. As a result, today virtually every protective relay offering is microprocessor based, but that's not the end of story. In fact, it is just the beginning because the real paradigm shift is just now coming into view.



What is it?
Communication and information technology:

To manage a modern power system in the economic environment of a global economy requires information. And to get information we need communications with the devices that make up the power system. Not just that, but we need time-tagged information from the devices that control the power system and collect the status, configuration, and health information of the power system. So where do we get that information and how?

To date, there have been numerous technologies from other industries that have been utilized to try and link, merge, and collate data from the various devices on a common power system. Most of these were never intended for the specific purpose of protection and control, and the ability to get information does not do any good if one cannot act on it reliably and do something with it. With the recently published IEC 61850 standard for communication networks and systems in substations, it is now possible to elevate the protective relay from just insurance to a necessary and critical component of the modern power system, even in the eyes of the most critical business manager.

The first true IEDs (intelligent electronic devices) for protection and control based on this new IEC standard are just now being introduced. With the promise of interoperability between vendors and use of proven and extendable communication technology, these devices will allow the protection engineer to truly optimize the performance of any power system where applied. Peer to peer sharing of common data and status allows complex schemes to be easily implemented at virtually no cost. Control schemes that were once applied to only the bulk transmission grid because of scale and costs can now be easily applied to distribution systems at the lowest voltages to increase reliability and new operational functionality.

We still have to give credit to those engineers in the past that invented and created the electromechanical marvels known as "silent sentinels." These served the industry well for the past 100 years and will still do so for some time, but the future of the electric power industry will hinge on the ability to control and adapt the power system economically and reliably for any disturbance or event whether it is environmental or self-perpetuated in nature. This new international standard provides the structure for this to be a reality. The challenge to those of us weaned on a load box and variac comes in how we can apply our skills on relays that interact in a virtual world of voltage, current, status inputs, and outputs. (Maybe they will make it into a video game? Right!) Refrain from retiring just yet; this standard has something for everyone. A component of this new standard provides for a common "Substation Configuration Language" that can describe all of the devices and equipment that make up the substation, its protection and control settings, and the interlocking of the various devices. This is accomplished by using defined object models that allow for self-description of any 61850 devices. This means for the first time generic testing tools can be made that can discover the structure of an IED, its settings, interlocking, and control functions, then configure an appropriate test, and test it closed loop. Even though this may be a few years away still, this is the future of relay testing, (sorry IED testing) and it will still require knowledgeable and skilled people to make sure these new fangled relays do what they are supposed to.

For the latest news on IEC 61850 and companies involved in providing these products, visit the Utility Communication Architecture – International Users Group website at: www.ucausersgroup.org or http://sharepoint.ucausersgroup.org.

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