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A Guide for Young Protective Relay Engineers

“Science is systemized knowledge. Art is knowledge made efficient by skill”.

Webster’s Collegiate Dictionary, Fifth Edition, G. and C. Merriam Co., Springfield, Mass., 1942

Opinion

FOLLOWING MY ELECTRICAL ENGINEERING EDUCATION at the Georgia Institute of Technology in Atlanta, GA I was in search of a career that was not only challenging but also stimulating and self-satisfying. I was fortunate to find just that with GE Energy in Schenectady, NY. Here I am in pursuit of earning the right to designate myself an official protection engineer. After working for nearly two years, I am here to share my experiences, challenges faced, and any advice I can offer for fellow young protection engineers.

Upon beginning my career at GE I was unaware I would be working in the field of relay protection. However, I accomplished many things while in school to prepare myself for this transition. On top of taking power courses I had two summer internships. The first was with Commonwealth Edison in Chicago, IL where I worked in the Research and Development department. I also had an internship in the NEETRAC high voltage lab in Atlanta, GA. In my nearly two years at GE I have completed seventeen generator protection coordination studies for large gas, steam, combined cycle and nuclear power plants in fourteen different countries. I have also participated in two WECC generator testing jobs where I obtained invaluable field experience.

Initial Discoveries

When I first began my career I found a solid foundation in electric power is an absolute must to be successful in protective relaying. Relaying demands a deep understanding of many technical aspects of power including: unbalanced power flows, fault currents, symmetrical components, bus configurations, trip circuits, machine design parameters and much more. A great knowledge base and deep understanding of these topics are not only invaluable but also necessary for a young protection engineer. This is a great field in which to begin a career because it forces you to fully understand these technical aspects of the power industry.

On a higher level, protective relaying has many unique aspects even when compared to similar fields in the power industry. First is that particular disparities found in the transition from schooling to the real world are greatly

amplified. Most young engineers leave school with the belief they will be cranking out cookie cutter design work that is defined within clear boundaries. A practicing protection engineer will encounter projects where the level of data supplied is highly variable. Some customers provide very little information and leave the engineer to design the system from scratch while others may provide specific setting limitations with strict boundaries. In school a student is always supplied the right amount of required data to find the solution. Additionally, the accuracy of the customer-supplied data can be inconsistent and is necessary to scrutinize in practice. A protective relay engineer must be able to cope with these variables not found in school.

A relay engineer’s ultimate outcome for a particular project comes down to creating settings that can generate a desired trip versus an undesired trip or failure to trip when desired. This is the facet where protective relaying begins to become more of an art than a science. Changing a setting by a tenth of an ohm can alter the outcome of an event drastically. This was

1 Mark by a rack of relays used for testing purposes



Protective relaying is the best power engineering career, because it ties together the strong technical aspects of power with business economics and efficiencies.

frustrating for me at first because engineering problems in school had one correct answer. Protective relaying solutions can be nearly infinite for particular problems. Most settings are created using best-practice methods and utilizing experience from previous projects.

One thing not considered in school is the fact that economics plays a huge role in designing protective relaying systems. The more relays, CTs, PTs and monitoring utilized in applications inevitably leads to a more expensive design. Therefore you are forced to keep designs economically feasible and be maximally efficient with the resources at hand. You must be able to justify every expense in the customers' eyes.

Challenges Faced

An unexpected aspect I soon discovered stems from the nature of the protective relaying industry. Protective relaying can be compared to the electric power version of insurance. Insurance has distinct characteristics and a stigma that follows it. Basically it's a necessary evil and expense in the consumer's eye. Relaying is not revenue earning, rather an expense that power equipment owners face. When problems occur such as faults or abnormal operations, they can result in catastrophic equipment damage, power outages and even bodily harm. These results demand quick and accurate action. In the worst-case scenario, when the protective relaying fails, the relay engineer must be able to explain the reasoning behind his or her work. The mere thought of this occurrence forces protection engineers to have a complete understanding of their relay settings. Enough so, for example, you can explain why your percent differential setting mistripped on an external fault due to a saturated CT because your slope 2 setting was set at 25%. It's like being backed into a corner and your only resource to successfully escape is to reason your way out by explaining your logic (Figure 2).

Advice

There are four keys to early success. First and foremost you need access and extensive use of power system reference and training material. This not only includes textbooks, relay manuals, IEEE standards and technical papers, it is necessary to stay current in the field by subscribing to magazines and relay manufacturer business updates.

Training courses tailored specifically for protective relaying are truly invaluable. Personally, I attended the Fundamentals of Modern Protective Relaying course taught by GE Multilin in Markham, ON. I was also fortunate enough to attend the Power and Energy Systems Engineering Course (PSEC) in Schenectady, NY on protective relaying taught by my mentor at GE, Mike Reichard. These courses are great for solidifying concepts and current practices. By far and away the most important resource is having a tried and true mentor who carries decades of experience under his or her belt. This is an absolutely priceless resource for many reasons. They are a walking encyclopedia and can supply immediate answers to questions. Their experience brings wisdom and practicality. A mentor will also have a constant supply of examples and know which projects are most helpful for the advancement of a young protection engineer.

In addition, it is vital for a young engineer to develop their network. The perfect resource to do that is to get involved in the IEEE in both technical committees as well as local activities. For young engineers a great resource is to join your local IEEE Graduates of the Last Decade (GOLD) affinity group. Since joining GE, a few coworkers and I formed a Schenectady section GOLD group. This is an ideal resource to network with peers in your industry.

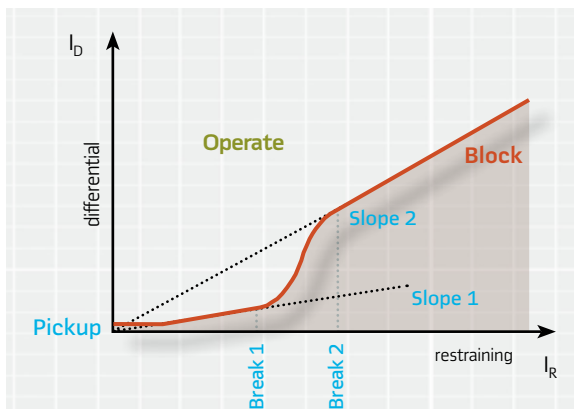
Future of the Industry

According to the IEEE Power Systems Relay Committee, the average age of a relay engineer is fifty-two and is increasing. This is a sign of a lack of hiring younger engineers and recent graduates. The future of the power engineering industry relies on the interests and minds of young engineers, some of who are still in school today. The field of protective relaying obtains little visibility in universities because it is a field with practices that have largely remained the same for decades. However, one aspect that has morphed through time is relays themselves. The advent of the microprocessor based digital relay in the mid-1980s is a point that should be emphasized to spark interest in students today.

Overall I cannot imagine a better field to begin a power engineering career than protective relaying. It ties together the strong technical aspects of power with business economics and efficiencies. The challenges it provides are endless and the learning process is ongoing. The need for new relay engineers is an emerging problem and must be met with modern incentives to correctly steer engineering students. The bible for protective relaying is C. W. Mason's *The Art and Science of Protective Relaying* and he quotes Webster's Collegiate Dictionary by stating "Science is systemized knowledge. Art is knowledge made efficient by skill." This is the perfect tagline to encompass the field of protective relaying. ■

For questions or more information please feel free to contact me via email at : markd.mcdonald@ge.com.

2 Example of a stator differential dual slope characteristic



Source: G60 UR Series Instruction Manual, Revision 5.6, GEK-113486

Mark McDonald graduated from the Georgia Institute of Technology in 2007 majoring in Electrical Engineering. During his studies, he performed research on transmission line dynamic rating systems. This research sparked his interest in electric power and the following summer landed an internship with Commonwealth Edison in Chicago, IL. He also had a summer internship in NEETRAC's high voltage test lab in Atlanta, GA. Mark is now a relay protection engineer at GE Energy in Schenectady, NY doing coordination studies on large gas, steam, combined cycle and nuclear power plants. Mark is involved in the local chapter of IEEE and has recently formed an IEEE GOLD affinity group. When not working, Mark enjoys traveling, skiing, rock climbing and watching Georgia Tech sports.