"STUDY OF ADVANCEMENTS IN LINE PROTECTION"

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Abstract - *Advancements in line protection and long-haul communications allow us to implement better line protection schemes to meet the increasing needs of modern power systems, facilitate savings in primary equipment, and reduce the cost of engineering. High-speed, affordable digital communications channels are key enablers of better and simpler line protection, with reduced engineering effort and lower risk of miscoordination.*

The advanced application of artificial intelligent approaches was introduced recently in protection of transmission line in electric power systems (eps).These approaches started with introducing fuzzy logic (fl) in the last decades of the last century. Furthermore, artificial neural network (ann) was introduced to tackle different problems.

In this presentation, we will first reflect on the role of line protection under stressed system conditions. We will discuss benefits and challenges of single-pole tripping as they relate to power system operations and their impact on primary equipment, protection schemes, cost, and risk. How does a utility make the decision to transition to single-pole tripping?

Finally, we will show how advanced protection can simplify processes and save costs on primary equipment.

I. ADVANCEMENTS IN LINE PROTECTION

A) CHALLENGES IN LINE PROTECTION

Let us look at some of the key challenges in line protection or power system protection in general.

First, power systems are operated closer to their limits with smaller transient stability margins, lower spinning reserve, marginal reactive power support, lower line loadability margins, and so on. As a result, protection systems are expected to work better than ever before in terms of speed, sensitivity, selectivity, and security.

Second, utilities are more sensitive to cost, workforce availability, and project schedules. Asan industry, we are expected to complete projects faster, at lower cost, and with fewer resources, often utilizing contract workforce.

B) POWER SYSTEM STABILITY MARGIN

Let us look at the power system margins and their impact on protection requirements. Two trends, gravitating in opposite directions, are clearly visible clearing faults faster and, at the same time, not tolerating misoperations.

The pressure on fault-clearing times has been addressed by the following:

- Improving protection response times
- Improving breaker failure coordination margins to reduce the total (critical) fault-clearing times (assuming the contingency of a failed breaker)
- Eliminating interposing relays in order to operate the breakers faster.

We have witnessed steady progress in all of these areas in the last several years. The pressure on continuous power transfer can be addressed with a shift from protection dependability to security and with a shift from three-pole to single-pole tripping. The former avoids undesired relay operations. The latter maintains power transfer during normal (desired) relay operations.

C) THREE POLE VERSUS SINGLE TRIPPING

The figure on the left-hand side of the slide shows the well-known power transfer curves for a normal system, a system with a fault, and a system with a major transmission line tripped three pole. Note that when the fault happens, the operating point (assuming constant mechanical power of a generator) shifts from the normal curve to the fault curve and farther to the curve for the three-pole auto reclosing. During this time, the generator accelerates because of the surplus of mechanical power over the reduced electrical power transfer capability. After reclosing, the operating point shifts back to the normal curve, providing more power transfer capability and facilitating deceleration of the generator rotor. The equal-area criterion tells us about transient stability. In the case shown, the system is marginally stable.

Compare this situation with the figure on the right-hand side of the slide. In this case, we assume single-pole tripping, which gives us much higher power transfer during the auto reclosing dead time. The accelerating area is much smaller, providing this system with a much greater stability margin.

Single-pole tripping improves transient stability by maintaining partial power transfer despite single-line-to-ground faults (slgf) on the system.

D) BENEFITS OF SINGLE POLE TRIPPING

When a single-line-to-ground fault occurs, the protective system should detect the ground fault and identify the faulted phase, tripping a single pole of the breaker to clear the primary arc Current. The open-pole period should be long enough to ensure that the secondary arc current (fault current fed by the energy from the other two phases) is extinguished.
Increased power system stability margins are the primary (but not the only) benefit of single-pole tripping and reclosing. Other important considerations include improved power quality (voltage sags), lower reclose stress on equipment (generator shafts), and reduced breaker wear (no need to operate all three poles of the breaker for a vast majority of line faults).at the same time, the cost of implementing single-pole tripping is just a few percent of building a new transmission line.

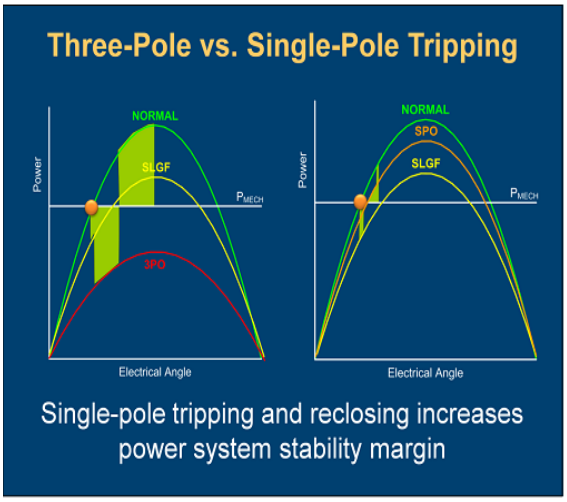
II. REQUIREMENTS FOR SINGLE POLE TRIPPING

There are several requirements for implementing single-pole tripping.

First, independent pole-operated breakers are required. This is typically not a problem because modern breakers are operated independently (in a mechanical sense). All that is required is to decouple the trip coils to trip on a per-phase basis. More importantly, four-legged reactors are required for secondary arc extinction. With two line conductors energized and feeding the faulted conductor via line mutual coupling, we need a way to extinguish the fault arc. Properly tuned reactors accomplish this by providing a resonating circuit that acts as a shunt at the system frequency for the arc voltage.

Finally, protection schemes must be capable of single-pole tripping and reclosing. This includes functions such as fault id logic, instantaneous tripping for the entire line (we must trip simultaneously, i.e., fast at both ends to facilitate auto reclosing dead time), detection of single-pole-open conditions and response to evolving faults, and breaker failure protection.

Most microprocessor-based relays allow for single-pole tripping and reclosing at no, or verylittle, extra cost. Note that the requirement to trip fast for 100 percent of the line length is practically a requirement of communications-assisted schemes.



III. THE CHALLENGES OF SINGLE POLE TRIPPING

The challenges of implementing single-pole tripping and reclosing are related mostly to the capital investment (breakers and reactors). When it comes to protection schemes, the relay incremental cost is relatively minor. Factors more consequential than the cost of relays include overall familiarity with the single-pole tripping relay philosophy, protection and control staff training, development and implementation of application standards and templates, development and implementation of test procedures, and impact on operations and maintenance. These are not trivial but manageable items. We need to keep in mind that the alternative way to accomplish the same benefits is to build new transmission line san activity much more expensive and organizationally more complex.

IV. DRIVERS FOR LINE PROTECTION BETTERMENT

Let us look at some of the new drivers for betterment of line protection, beyond faster trip times and increased sensitivity.

First, nonstandard sources, such as doubly fed machines or power electronic (inverter-based) sources, change the characteristics of fault currents in the system. The different fault current response challenges some of the tried-and-true protection principles.

Second, better line protection allows the relaxing of some of the requirements for the primary equipment, including savings in line construction related to tower grounding and line shielding.

Third, savings in unification and simplification are drivers that lead to real and measurable benefits. Finally, leveraging modern communications allows simpler protection schemes that perform better.

V. CONCLUSION

To summarize this introduction to our line protection advancement discussion, some of the key take aways include the following:

1) digital communication is a key enabler for advanced line protection. Speed, Bandwidth, self-monitoring, and security are key differentiators compared with older communications technologies for line protection.

2) saving in engineering & other cost becomes an important consideration in today's business environment.

3) savings in primary equipment are possible through improved protection schemes, primarily sensitivity and dependability.

VI. REFERENCES

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