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Increased security and maximized utilization

Protection and system security improvement in Ghana

At a glance

Rapidly increasing load growth is a major challenge and driver for large-scale system expansion in Ghana. In the last five years the transmission system operator, GRIDCo, increased its transformer capacity by over 50 per cent. Even so, the transmission system is often forced to operate close to its limits due to a lack of generation capacity. In the past, mal-operation of the protection system and cascading events were observed. Considering low critical fault clearing times, the situation poses a high risk of total system blackout in case of failure of the primary protection system.

In order to reduce the risk of system collapse, GRIDCo initiated a system-wide protection system review. The objective was to ensure system security and to maximize the utilization of the system through improvement of the performance of the protection system.

Initial situation and challenge

In general, protection settings were calculated by different substation vendors or consultants. The protection system model and settings were not available in a central database or power system simulation software. No system-wide coordination and check of protection settings was possible.

The following tasks and workflow were defined to review and improve the existing systems' performance:

- review of existing protection system and generation system stability to achieve performance improvements
- development of enhanced protection schemes and relay settings calculation guidelines
- calculation of new improved settings and verification of their performance through simulation
- definition of short-term actions, and a medium- and long-term strategic protection system development plan

The solution

Power and Protection System Modeling:

A detailed power and protection system model was built and benchmarked with GRIDCo's existing PSS®E model. The geographic system model that was developed includes a detailed internal substation model with all circuit breakers (CBs), current transformers (CTs), voltage transformers (VTs) and protection relays.

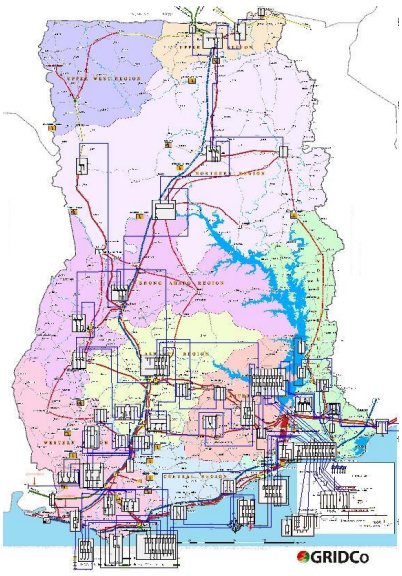

Figure 1: Power and protection system model

GRIDCo

GRIDCo is the national interconnected transmission system operator of Ghana. Its mission is to provide reliable, secure, and efficient electricity transmission services and wholesale market operations to meet stakeholder expectations within Ghana and the West African Sub-region, in an environmentally sustainable and commercially viable manner.

> “The project results covered all required aspects of the Terms of Reference and contain important information for an improved network protection system. We are looking forward to continue our business relationship with Siemens PTI.”
>
> Dr. Thomas Ansah, CEO at GRIDCo

All protection setting parameters were collected in the field and imported into the system model. The zero-sequence and mutual coupling was amended to simulate single-phase faults with the highest possible accuracy. The model building process was complemented with multi-level data plausibility checks for highest data quality.

Scenario Building: To systematically assess protection system performance, a multitude of fault scenarios with varying fault location, type and arc resistance were defined.

Simulation and Performance Assessment: Siemens PTI’s SIGUARD PSA (Protection Security Assessment) solution was used to simulate selectivity, sensitivity and speed of the protection system. In each scenario, all stages of the entire fault clearance sequence were simulated in detail. This provides deep insight into the protection system response for a given fault condition. All currents, voltages and impedances measured by protection devices are available.

Generation system stability was assessed for the existing and newly proposed and improved under-frequency load shedding schemes, taking into account different system configurations. In total, hundreds of thousands of fault scenarios were simulated. The results were automatically assessed and visualized in a concise way with SIGUARD PSA.

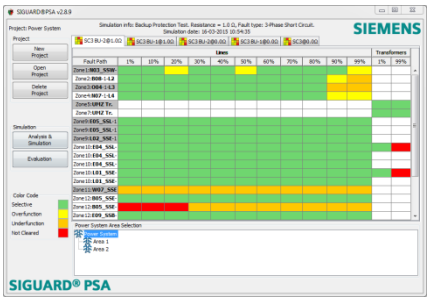

Figure 2: SIGUARD PSA protection performance visualization (color code: red - fault not cleared, orange/yellow – over-/underfunction)

In this state-of-the-art approach, the protection system performance is assessed by simulation, and not only using the classical approach of solely depicting setting values. The new methodology sets itself apart from the conventional, and individual, evaluations of distance, differential and overcurrent time relay characteristics by assessing the combined ‘system’ response with all main and back-up protection relays in the power system.

The quality of the protection system performance is depicted by color-coding that is meaningful for both technical and non-technical staff. Results can be aggregated for complete network regions or detailed for individual power system components or protection relays. This allows the identification of incorrect settings, weaknesses and limitations of protection system.

The high degree of automation enables the efficient assessment of a very large number of fault scenarios and complex system conditions, and minimizes the individual treatment of special cases.

Protection System Improvement: False or improvable protection settings were corrected using a rule-based algorithm. The underlying protection grading rules were improved by iterating simulation, assessment and setting improvement until optimum results were reached. In this way, system-wide coordination and optimization of the protection settings was achieved. In addition, the quality of the new protection settings is ensured before approval.

Key achievements

The benefits of the systematic protection system review and improvement project were:

- complete data survey, documentation and modeling of the power and protection system with validated high quality
- assessment of the performance of the existing protection system, showing its specific characteristics, behavior, weak points and limitations
- development of newly improved protection settings, grading rules, scheme recommendations and an under-frequency load shedding scheme based on the review findings. Validation of new settings by simulation before approval
- recommendations for the efficient future strategic development of the protection system
- knowledge transfer for staff through regular workshops and customized training

It was demonstrated that the adaptation of protection settings can help increase system security and maximize utilization of the existing system, which in turn avoids CAPEX investment.

Published by
Siemens AG 2017

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