Technology Innovation Project

Closing Project Brief

TIP 314: End-Use Testing and Model Development

Context

While computer models for transmission elements and generators have been greatly advanced over the past 40 years, load models have been substantially lagging.

Western Interconnection has made significant advancement in dynamic load modeling in the past 10 years. A composite load model was developed, tested and implemented in all major production-level grid simulators used in Western Electricity Coordinating Council (WECC). Bonneville Power Administration and Southern California Edison played the leadership role in the model development, testing, validation and deployment. WECC approved the Phase 1 composite load model for planning studies in the 2014 study program.

Although air-conditioner models were developed as a part of the composite load model, a stall feature was not included for assessment studies in the phase 1 roll-out.

Studies performed for Portland metro area indicate that along with growing air-conditioning load, delayed voltage recovery and risk of system over-voltages are increasing. Underrepresentation could be very expensive as dynamic reactive devices are needed for mitigation. Additional risk-based planning studies are needed as well as further research to ensure models adequately represent air-conditioner stalling.

Description

This project performed the following tasks:

Additional Testing of Air-Conditioners and their Controls: The data was analyzed and used for model validation.

Point-on-Wave Model Validation: The test data was used to develop appropriate data sets and to validate the models that can then be used to generate a manifold of air-conditioner stall characteristics, as a function of voltage dip, duration, point-on-wave and crank position. This establishes a diverse set of motor stall thresholds.

Deterministic Feeder Aggregation and Motor Benchmarking: A simple feeder model was developed in the PSLF program to simulate a wide variety of faults. When results were compared with an aggregated model, the impact of aggregation on the simulations of air-conditioner stalling phenomenon were able to be determined.

Statistical Feeder Aggregation and Motor Benchmarking: By including statistical diversity of the air-conditioner stalling phenomenon in the LD1PAC model, we could determine whether statistical modelling gave a closer prediction of motor stalling phenomenon.

Benchmarking against actual events: All developed models were benchmarked against actual events at two levels:

- Service entry using data collected by Southern California Edison
- Large scale FIDVR events

Recommendations on how to proceed with Phase 2 will be made based on benchmarking and sensitivity studies.

Benefits

It is important to understand the risks associated with Fault-Induced Delayed voltage recovery (FIDVR) exacerbated by increasing air-conditioning loads. Although the exposure window for large scale FIDVR is small (40 hours mean, up to 120 hours) relative to southern states where most FIDVR occurrences are recorded, initial studies show that FIDVR transient performance could become a limiting factor if air-conditioning loads keep growing.

Investments to mitigate FIDVR are very expensive, as they require dynamic voltage support. At the same time, wide-spread outages are also very expensive particularly on extreme hot days. This project continues to improve the composite load model the BPA relies on.

Accomplishments

The goal of this project was to promote revisions to the air-conditioner component of the composite load model.

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Project Start Date: October 1, 2014

Project End Date: December 31, 2017

Funding

Total Project Cost: $540,000

Deliverables

Project deliverables include:

- Air-conditioner test report, including new elements such as sensitivities with respect to initial voltage, fault voltage, fault duration, recovery voltage, point on wave where a fault is applied;
- Electronically commutated motors test report;
- Code for single-phase AC model, sensitivity studies of motor stalling with respect to initial voltage, voltage sag magnitude, sag duration, recovery voltage, point on wave and crank shaft position where a fault is applied;
- Feeder model, runs with deterministic and statistical models; and
- Model validation report for aggregated residential air-conditioner model

For More Information Contact:

Technology Innovation Project Management Officer:
TechnologyInnovation@bpa.gov

Participating Organizations

Western Electricity Coordinating Council (WECC)

Results

An induction motor model, *motorld*, was developed for use in GE's transient stability program PSLF. The model consists of a set of differential equations and includes the following protection functions: an aggregate motor protection module consisting of motor contactors and a control tripping function. The model is included in the latest PSLF release.

Several tests were performed to determine the dynamic performance of the *motorld* model in response to frequency and voltage inputs. The response of the model was compared against measured signals. The results obtained show that the motor model can be used to simulate the dynamic response of three-phase induction motors.

The PSLF single-phase induction motor model, *ld1pac*, was updated to include a revised stall threshold logic for computing transition from "run" state to "stall" state.

In addition, the PSLF single-phase induction motor model, *motorc*, was revised to include the same contactor, under-voltage relay, and thermal protection logic as the *ld1pac* model. Simulation results comparing the model response with and without protective devices, for several scenarios, are included.