



Improved Dynamic Load Modeling Using Power System Measurements for Enhanced Transmission and Distribution System Operation and Planning

Final Project Report

S-80

Power Systems Engineering Research Center
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Executive Summary

The project uses point on wave measurements made in power system following disturbances of different types and severity to first determine accurate three-phase load composition along distribution feeders. Based on the detailed three-phase load composition characterization obtained, more accurate load compositions for conducting positive-sequence time domain simulations will be developed. The operational and planning benefits of more detailed load compositions in making electric utilities more competitive will be quantitatively evaluated.

This project is collaboration between Arizona State University and Texas A&M University. The project report is composed of contributions from both universities. The first part of this project, title “Load Synthesis in Distribution Feeders Using Point on Wave Measurements”, is presented from Chapter 1 through Chapter 5. The second part, title “Enhanced Transmission and Distribution System Operation and Planning with Improved Dynamic Load Modeling”, demonstrates the benefits and applications of the advanced load models established in the first part of this project.

With the increasing penetration of renewables in the distribution systems, the need to address the challenges of load modeling is becoming essential. Some of these challenges include obtaining an accurate and a realistic representation of the aggregated load model parameters and the load composition to represent the feeder and load models in grid studies. With an emphasis on tackling these issues in the topic of load modeling, this report presents the following intermediary steps in developing accurate load models:

1. Synthesis of a three-phase standard feeder and load model using the measured voltages and currents, for events such as faults and feeder pickup cases, obtained at the head of the feeder.
2. Synthesis of more accurate three-phase feeder and load models at different substations using the standard feeder and load model developed in Step 1.
3. Investigated issues relate to motor stalling phenomenon in positive sequence software packages (such as PSLF) and proposed an analytical approach to estimate the motor stalling in PSLF.

In the first phase of this project, a standard feeder and load model had been synthesized by capturing the current transients when three-phase voltage measurements (obtained from a local electric utility) are played-in as input to the synthesized model. The comparison between the measured currents and the simulated currents obtained using an electromagnetic transient analysis software (PSCAD) are made at the head of the designed feeder. The synthesized load model has a load composition which includes impedance loads, single-phase induction motor loads and three-phase induction motor loads. The parameters of the motor models are adjusted to obtain a good correspondence between measured three-phase currents and simulated current responses at the head of the feeder when subjected to events under which measurements were obtained on the feeder. These events include faults which occurred upstream of the feeder at a higher voltage level and a feeder pickup event that occurred downstream from the head of the feeder. Two different

load compositions have been obtained for this feeder and load model, depending on the types of load present in the surrounding area (residential or industrial/commercial).

The second phase of this project develops a more systematic algorithmic approach to obtain better feeder and load model based on the substation it originates from and at different loading conditions (in summer and winter). The standard feeder and load model obtained from the first phase of this project is used as the starting point to apply the proposed algorithmic approach to obtain more accurate feeder and load models. Like the first phase of this project, both load parameters and load composition have been determined for these feeder and load models depending on their physical location and the nature of the load supported by these feeders.

In the third phase of this project, the impact of feeder and load modeling studies in positive sequence time domain simulation environments such as PSLF has been investigated. One of the feeder and load models obtained from the second phase of this project has been used to study the motor stalling phenomenon issues in PSLF. An analytical approach based on multi-variable linear regression has also been proposed in this work to estimate motor stalling in PSLF accurately.

In the remaining phase of this project, we study the enhanced transmission and distribution operations and planning due to improved dynamic load modeling. In particular, Chapter 1 of Part 2 studies the enhanced operation in distribution grid with more accurate three-phase load composition information. Chapter 2 of Part 2 presents an enhanced transmission operation by look-ahead coordination reactive power support devices. Chapter 3 of Part 2 proposes a new business model for the future distribution utilities by explicitly accounting for the “grid-friendliness” of individual customers.

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