

ETAP Transient Stability Validation Cases and Comparison Results

Case No. 5

Sequential Motor Dynamic Acceleration Simulation

ETAP TS V&V Case Number TCS-TS-181

Comparison with PTI PSS/E Simulation Results

Highlights:

- Comparison of simulation results between the ETAP Transient Stability simulation results and PTI PSS/E program.
- Sequential motor dynamic acceleration study involving six motors.
- An islanded system with no power grid support
- ETAP built-in salient-pole subtransient synchronous generator model.
- ETAP built-in IEEE ST2 excitation/AVR model.
- ETAP User-Defined Dynamic Model (UDM) for Woodward Diesel engine/governor model.
- ETAP built-in double-cage induction machine model.
- ETAP Transient Stability program simulation results compared to the PSS/E results.
- Comparison includes generator real, reactive and mechanical power, exciter voltage, generator speed, and induction motor terminal voltage and slip.
- Nearly identical results from ETAP and PSS/E.

1. System Description

The system includes a generator and a group of induction motors as shown in Figure 1. The diesel unit generator is rated in 1.87 MW, and modeled in ETAP with Subtransient salient-pole type. Exciter/AVR is modeled with ETAP built-in IEEE Standard ST2 type, and Turbine/Governor is modeled with ETAP User-Defined Dynamic Model (UDM) Woodward Diesel type, shown in Figure 2. The induction motors ratings are ranged from 225 to 400 HP, and dynamically modeled with ETAP double-cage integrated bars type.

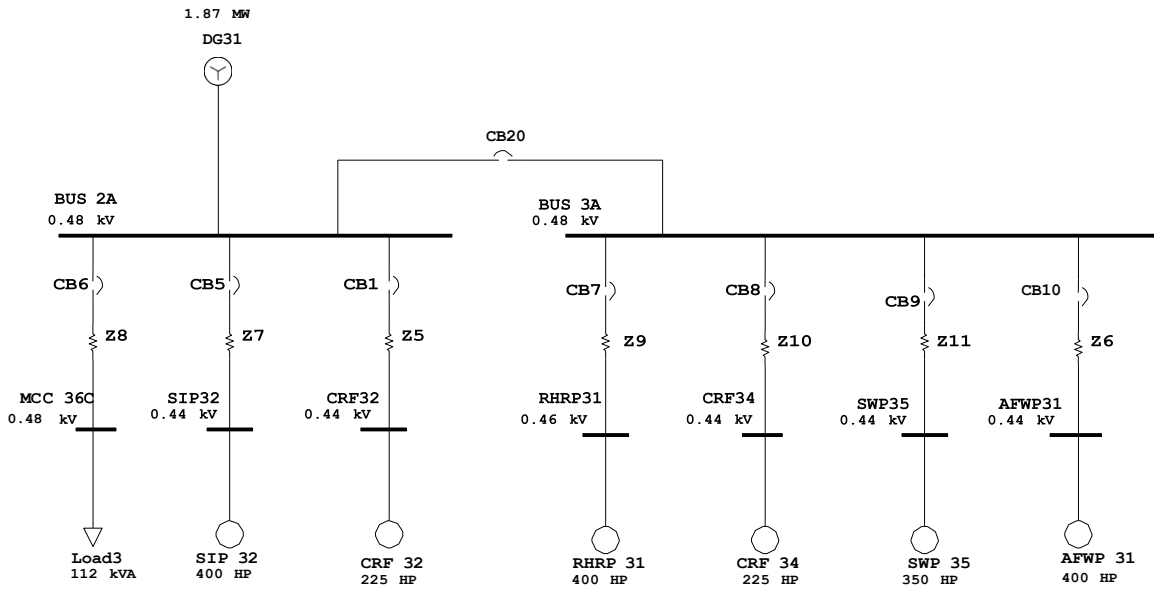


Fig. 1. Sequence Motor Dynamic Acceleration Simulation Study System

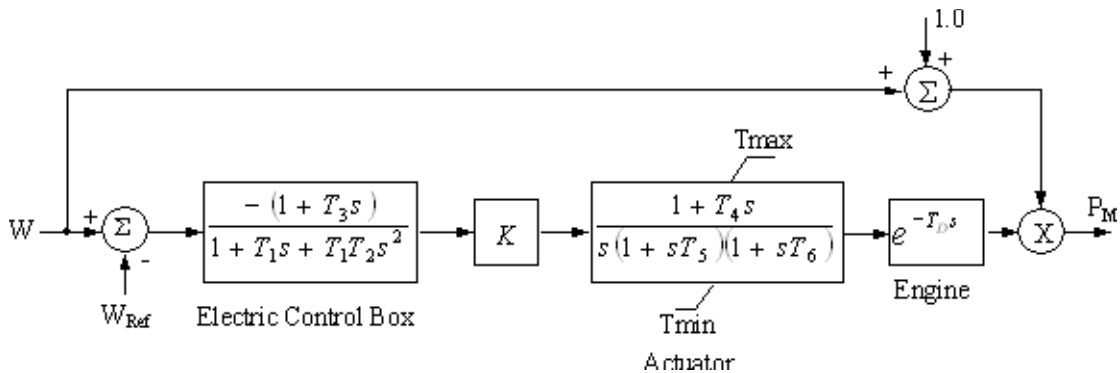


Fig. 2. ETAP UDM Woodward Diesel Turbine/Governor Model

2. Simulation Events

The simulation events on this system are scheduled to start-up one-by-one all six induction motors with 5 second intervals between each starting.

3. Simulation Result Comparisons with PTI PSS/E

In this study, the generator and motor simulation results, including generator real, reactive and mechanical power, generator speed deviation, exciter voltage, motor voltages and slips are compared with the results by PTI PSS/E. The following plots (Figures 3-10) show the result comparisons between ETAP and PSS/E.

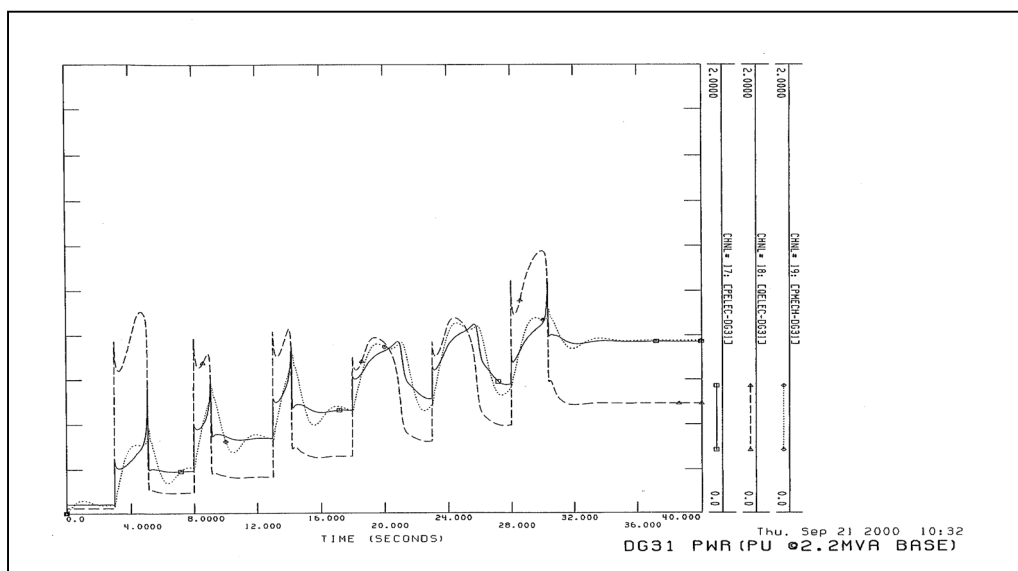


Fig. 3. Generator Real, Reactive, and Mechanical Power by PSS/E

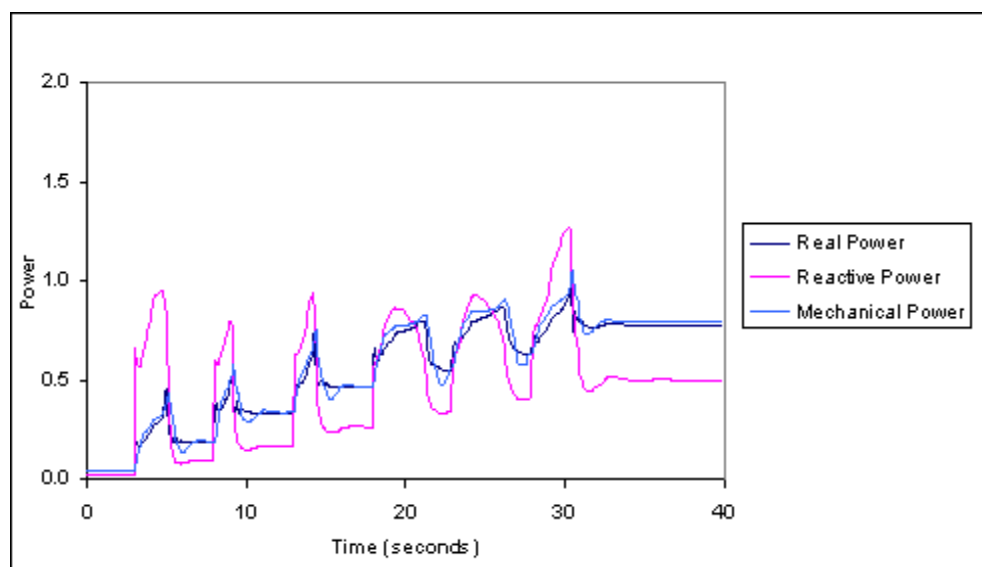


Fig. 4-1. Generator Real, Reactive, and Mechanical Power by ETAP

Simulation results for generator real and reactive power outputs and mechanical power input in Figures 3 and 4-1 show a very close agreement between the two simulations in terms of their peak values, final values, rising time, and overall

response shapes. Note that the PSS/E results show a spike-like motor inrush in the generator reactive power curve at the beginning of each motor acceleration, which are not present in the ETAP results. In the ETAP simulation results, these motor inrush values are present for each individual motor reactive power demand (Figure 4-2), but not for the generator since the overall demand on the generator includes the combined effects of the starting motor inrush and the normal reactive power demand of all the previously started motors, which are running.

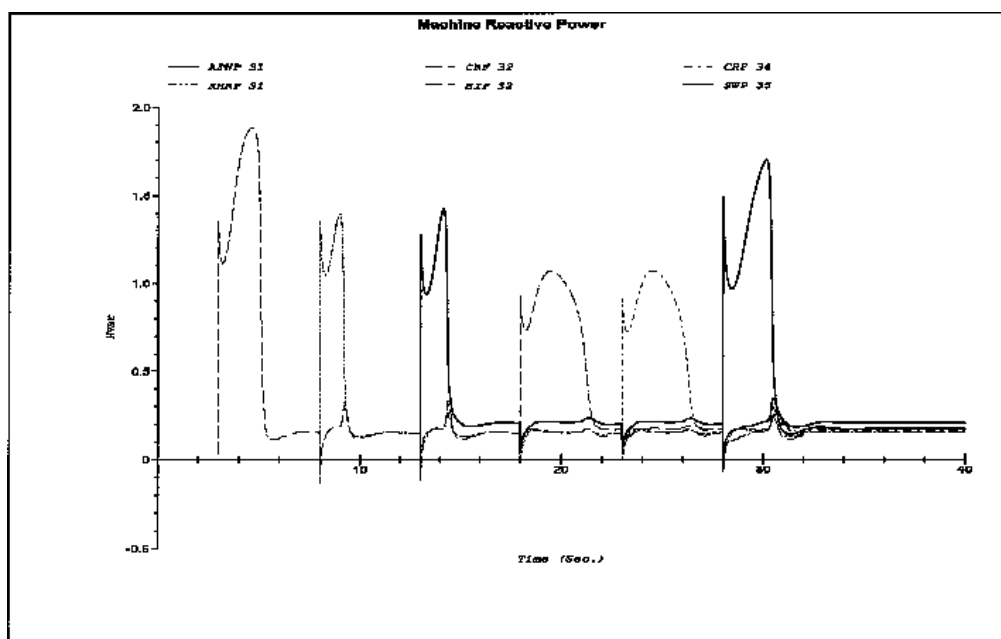


Fig. 4-2. Motor Reactive Power by ETAP

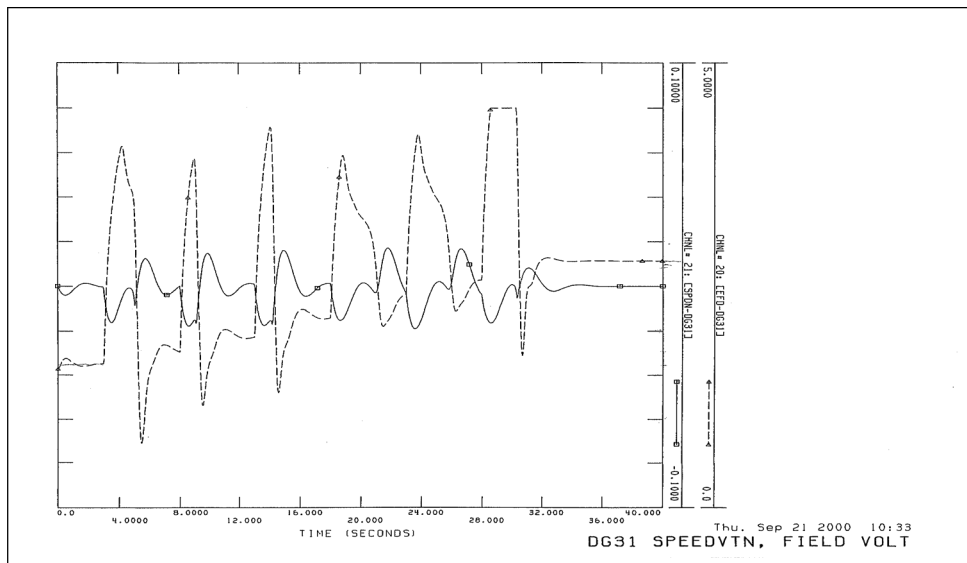


Fig. 5. Generator Exciter Voltage and Speed by PSS/E

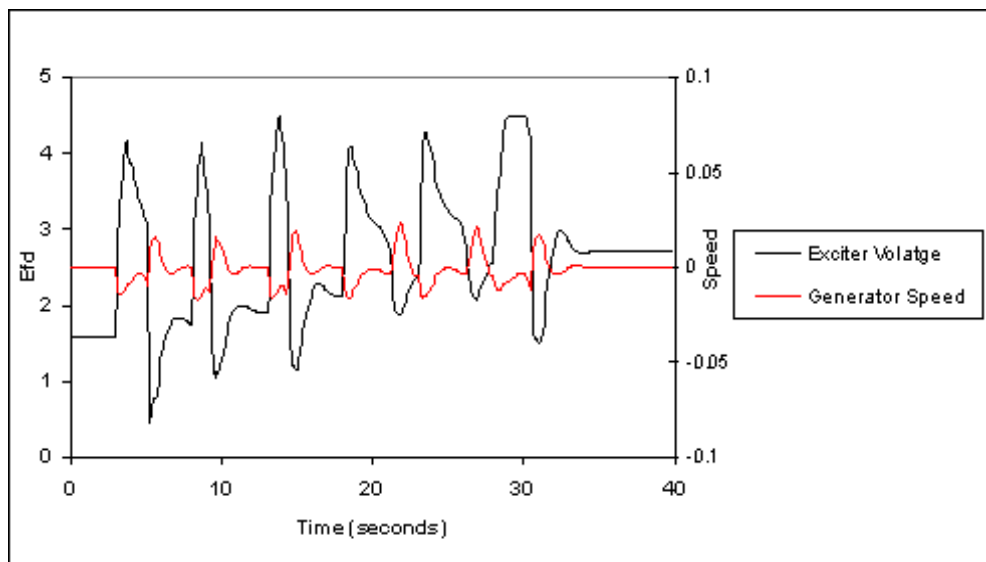


Fig. 6. Generator Exciter Voltage and Speed by ETAP

Figures 5 and 6 show a comparison for generator exciter voltage and speed responses. No significant difference is noticed between the two simulation results. It is pointed out that the initial load flow condition is not stable in the PSS/E simulation results.

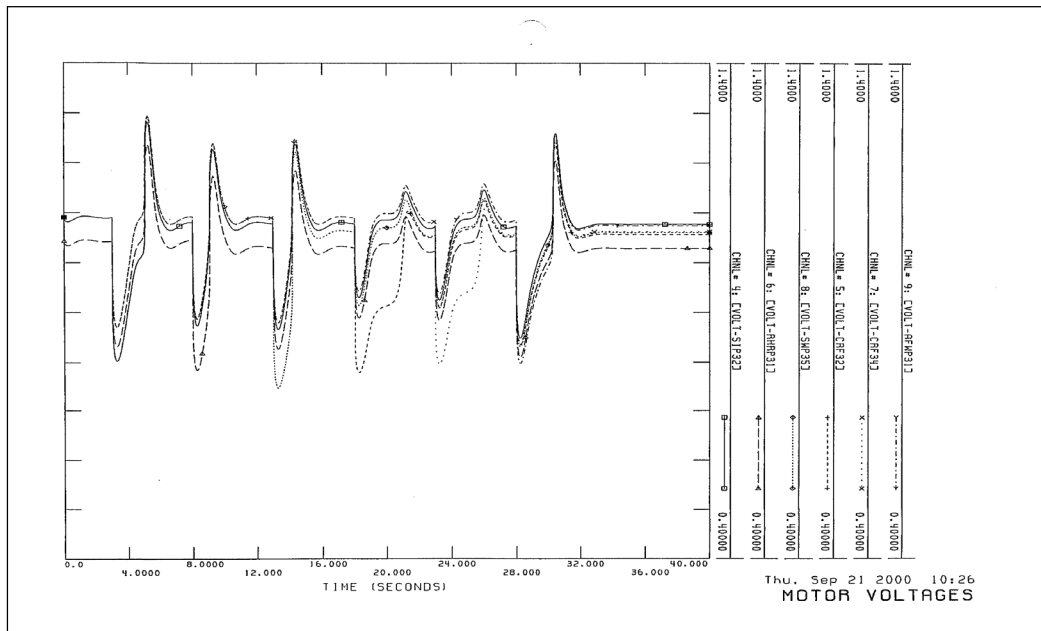


Fig. 7. Induction Motor Terminal Voltages by PSS/E

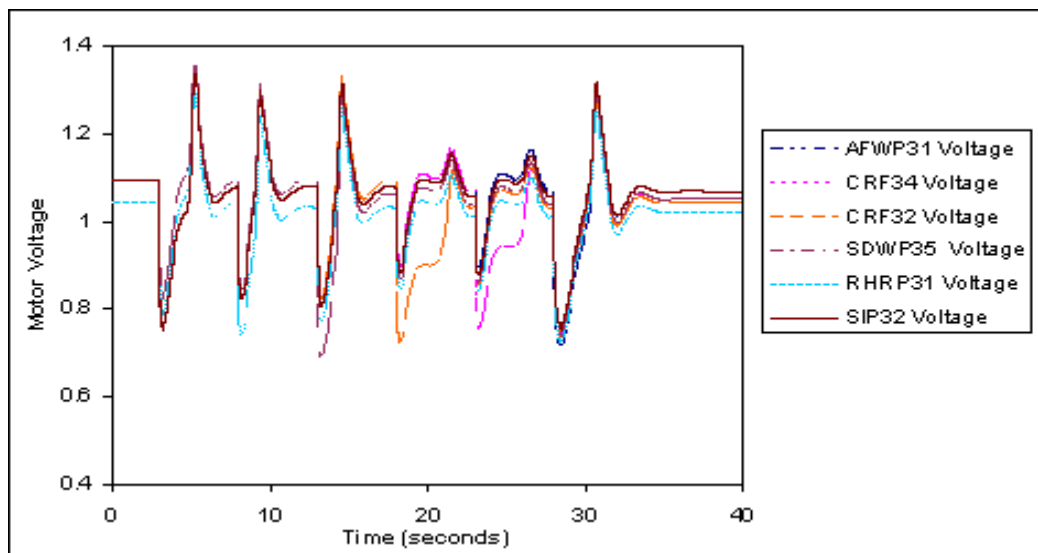


Fig. 8. Induction Motor Terminal Voltages by ETAP

The motor terminal voltage responses for all six accelerating motor buses display the same patterns and values in both simulation, shown in Figures 7 and 8.

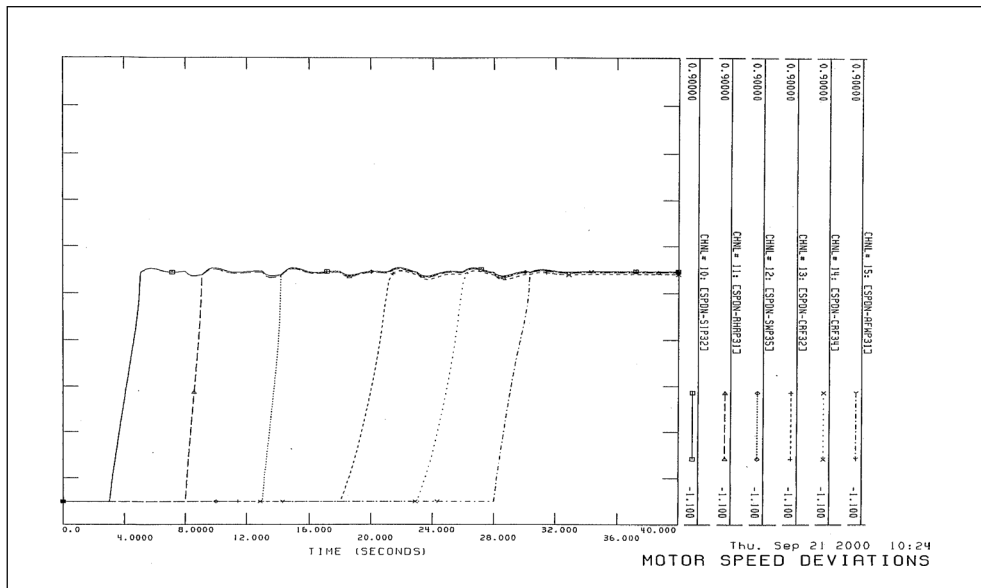


Fig. 9. Induction Motor Speed Slips by PSS/E

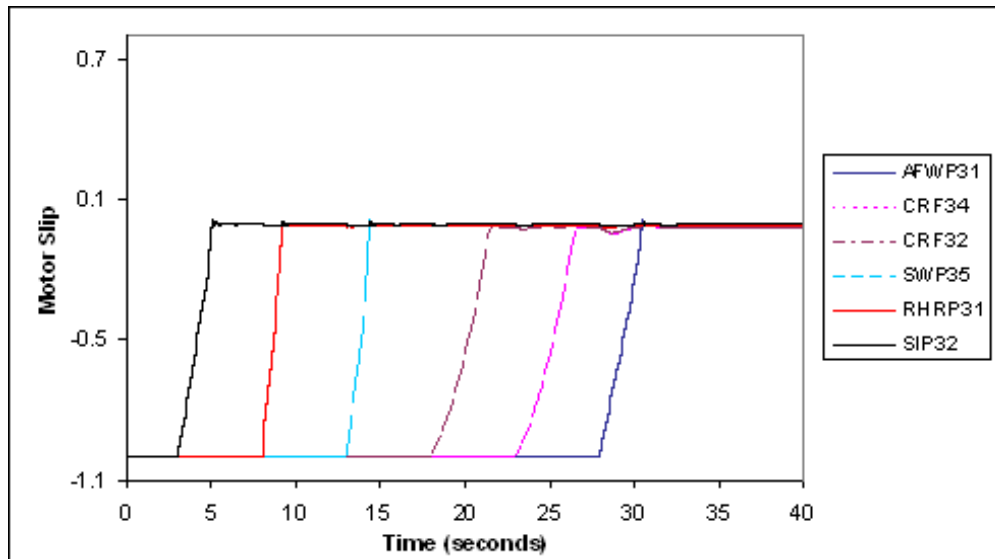


Fig. 10. Induction Motor Speed Slips by ETAP

The motor slip response curve comparison in Figures 9 and 10 shows the motor acceleration time and final slips for all six accelerating motors are almost identical. Note that the motor slip is defined here as $(\omega_{mtr} - \omega_{sys}) / \omega_{sys}$, which is normally defined as $(\omega_{sys} - \omega_{mtr}) / \omega_{sys}$.

4. Conclusions

A comprehensive comparison between ETAP and PSS/E results clearly shows that both programs provide almost identical results.

Reference:

ETAP Transient Stability V&V Documents, Test Case Number TCS-TS-181, 2023.