

# Integration and Demonstration of Marine Energy Models in Dynamic Stability Simulations

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## Wave Energy & Dynamics Grid Simulations

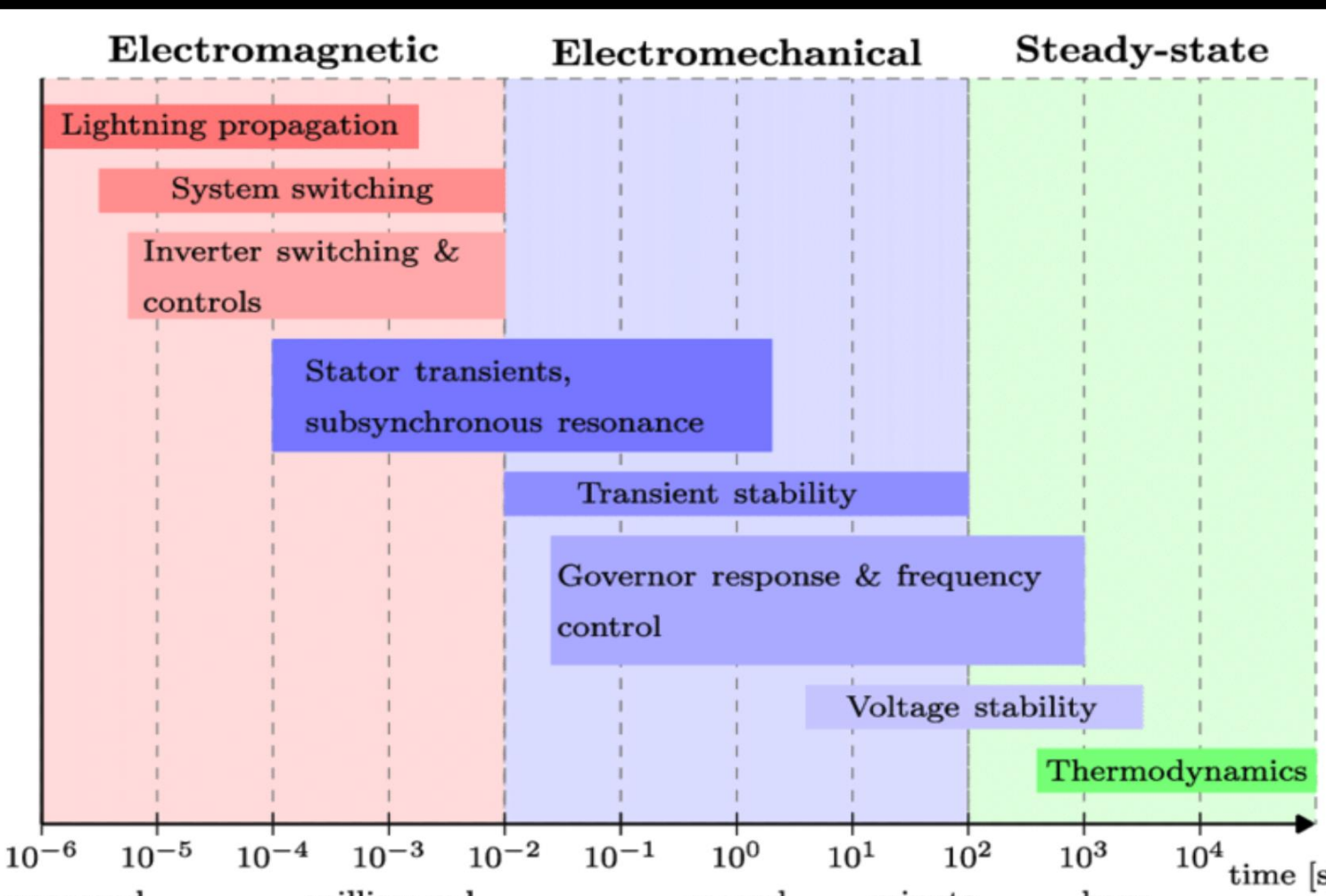


Fig 1. Power System simulation time scales

### Challenges

- Intermittent energy resource
- Non-dispatchable

### Tools

- Steady-state simulation, Quasi-steady-state-simulation
- Dynamic (time-domain) simulation

### WEC integration studies

- System behavior & stability
- Case studies with grid scenarios, WEC devices, and diverse load profiles

## Model Runs & Technical Contribution

### Model runs

- Modified IEEE-14 bus test case to include Wave Energy Converter (WEC) Power Take-Off (PTO) located at bus 8.
- Regular wave time-series input to PTO during simulation.
- Simulation with line outages, faults, and power perturbations.

### Contributions

- Linear PTO Model module in PowerDynamics.jl.
- Extension of PowerDynamics.jl support time-series.
- Full WEC PTO integration time-domain simulation.

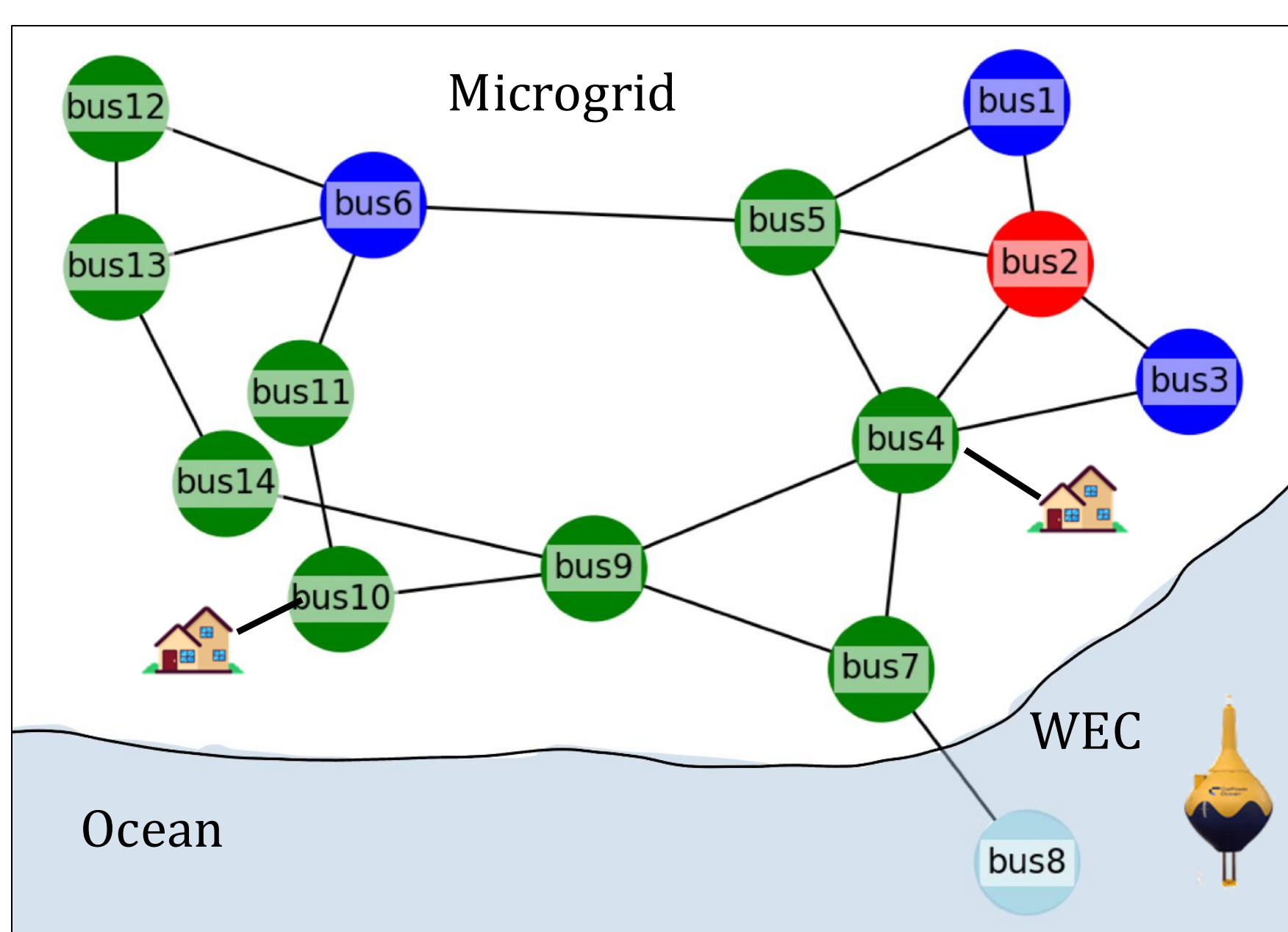


Fig 2. WEC adapted IEEE 14 test grid network

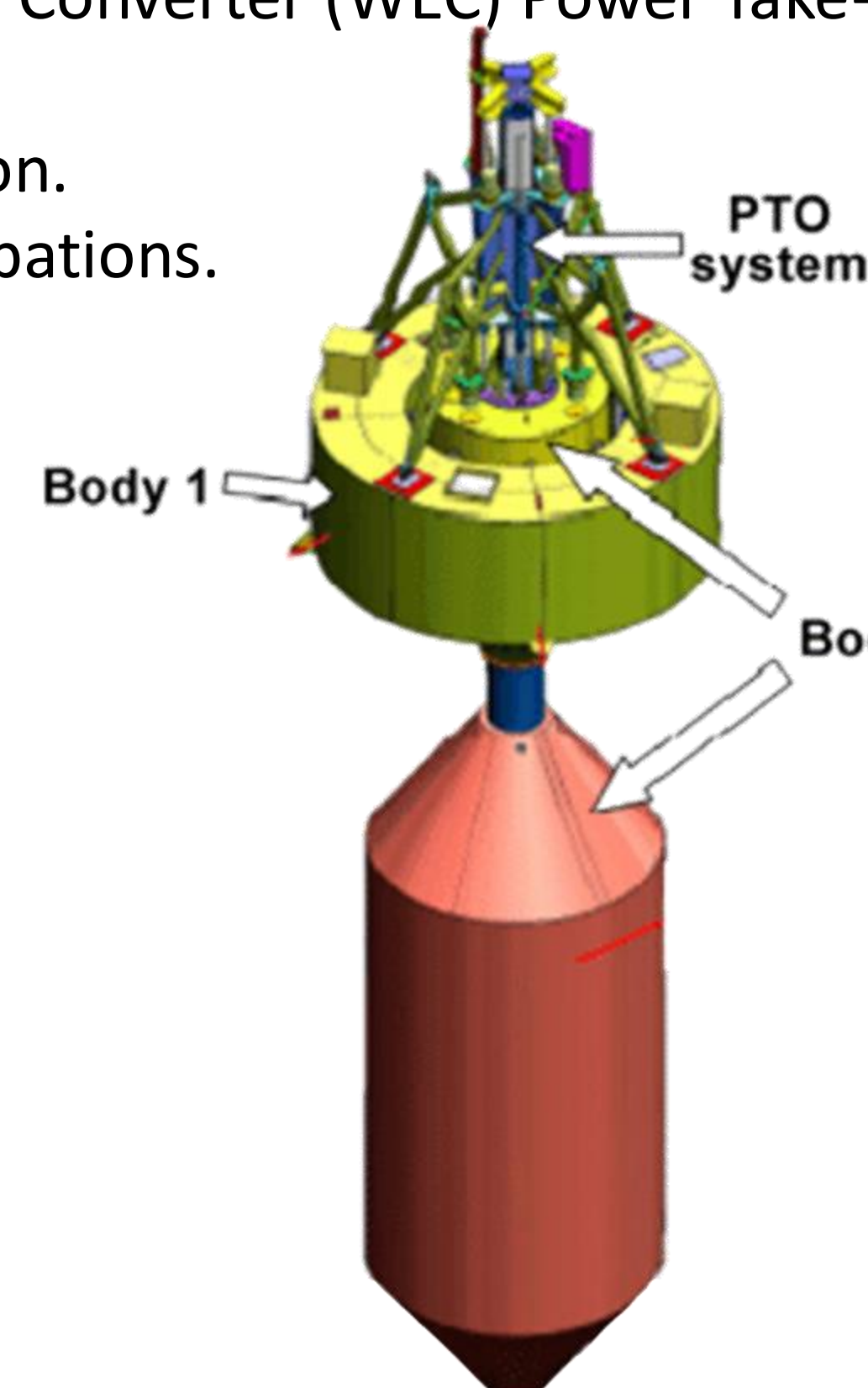


Fig 3. Two-body wave energy converter with PTO system

## Key Insights & Future Work

- Stable grid conditions with various faults and line outages using PTO.
- Investigate non-converging test cases.
- Scaled simulations to include a WEC farm on a larger system.
- Irregular wave test.
- WEC-SIM integration.

## Results

### Simulation 1 details

- 30-second dynamic simulation with a variable step size.
- At  $t = 10$  line outage between bus 1 and bus 2.
- Line reconnecting at  $t = 15$ .

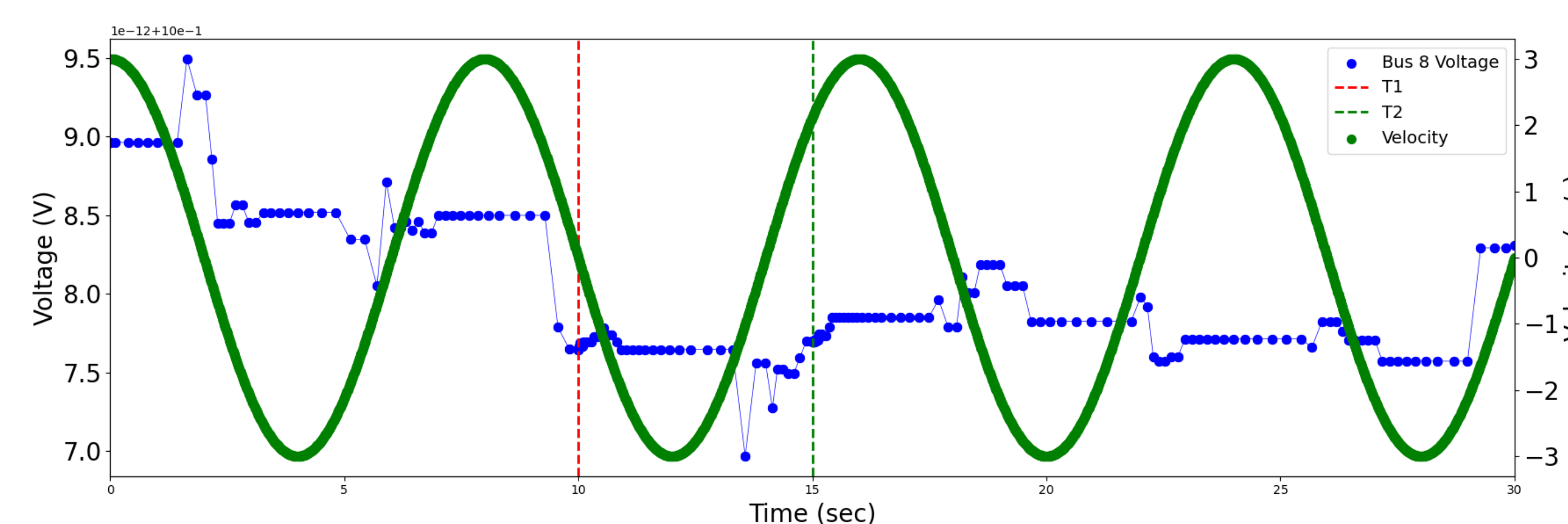


Fig 4. Bus 8 voltage and WEC velocity with line failure

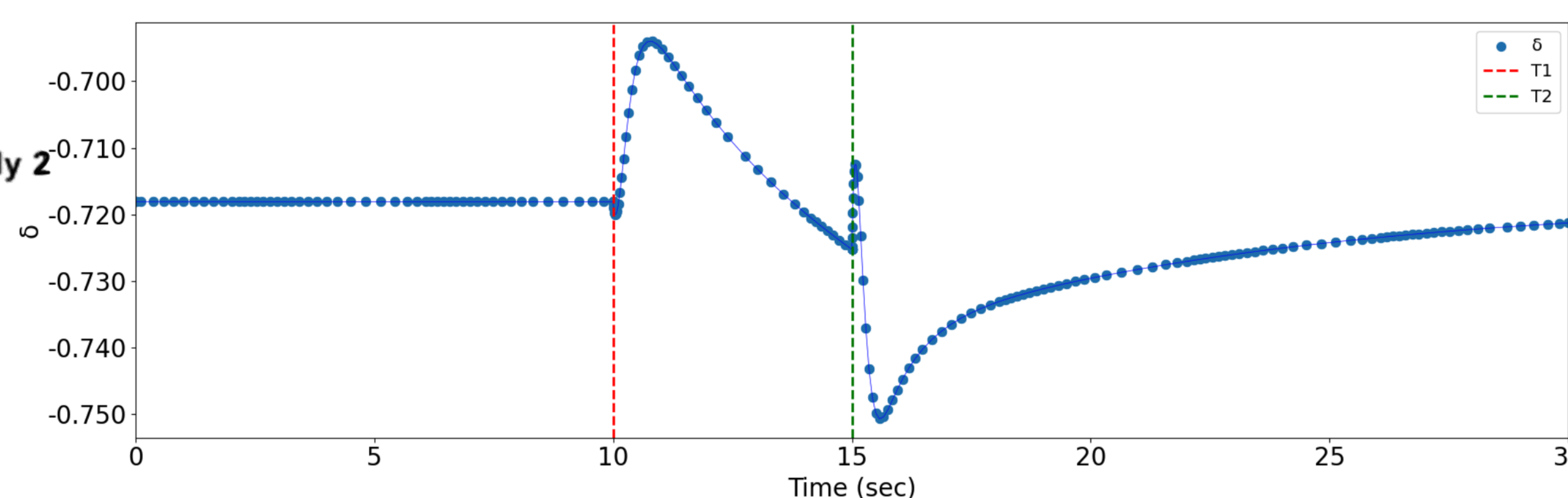


Fig 5. Bus 8  $\delta$  with line failure

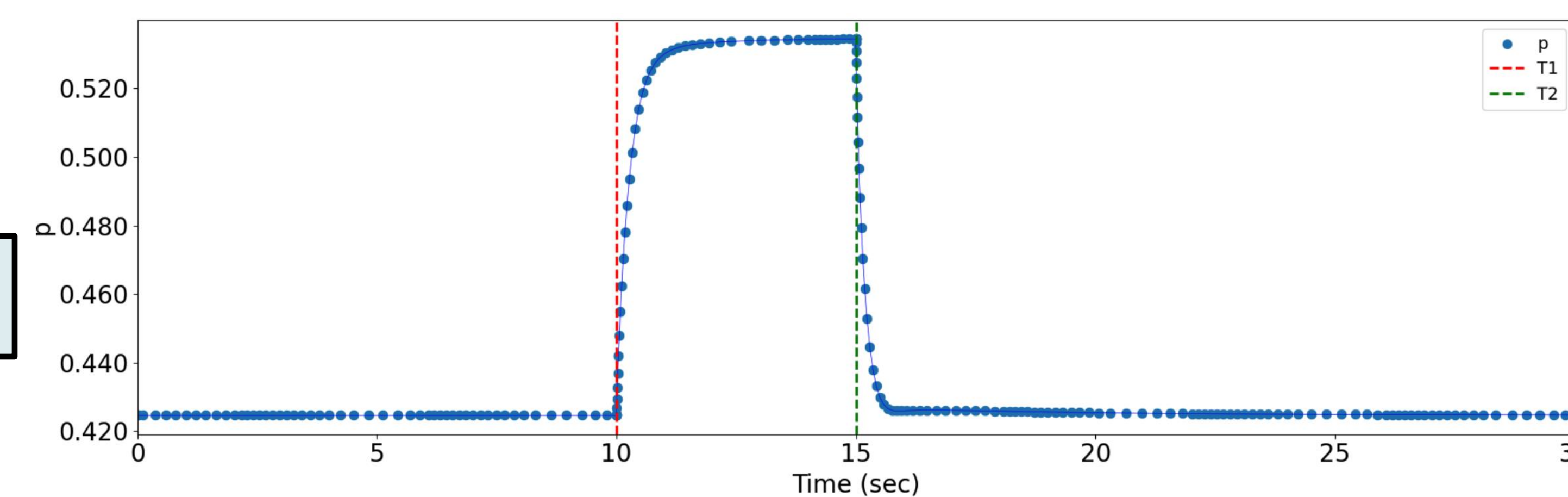


Fig 6. Bus 8 active power with line failure

### Simulation 2 details

- 30-second dynamic simulation with a variable step size.
- Active power at bus 3 is set to 1.0 from  $t = 10.0 - 15.0$ .
- Line reconnecting at  $t = 10$ .

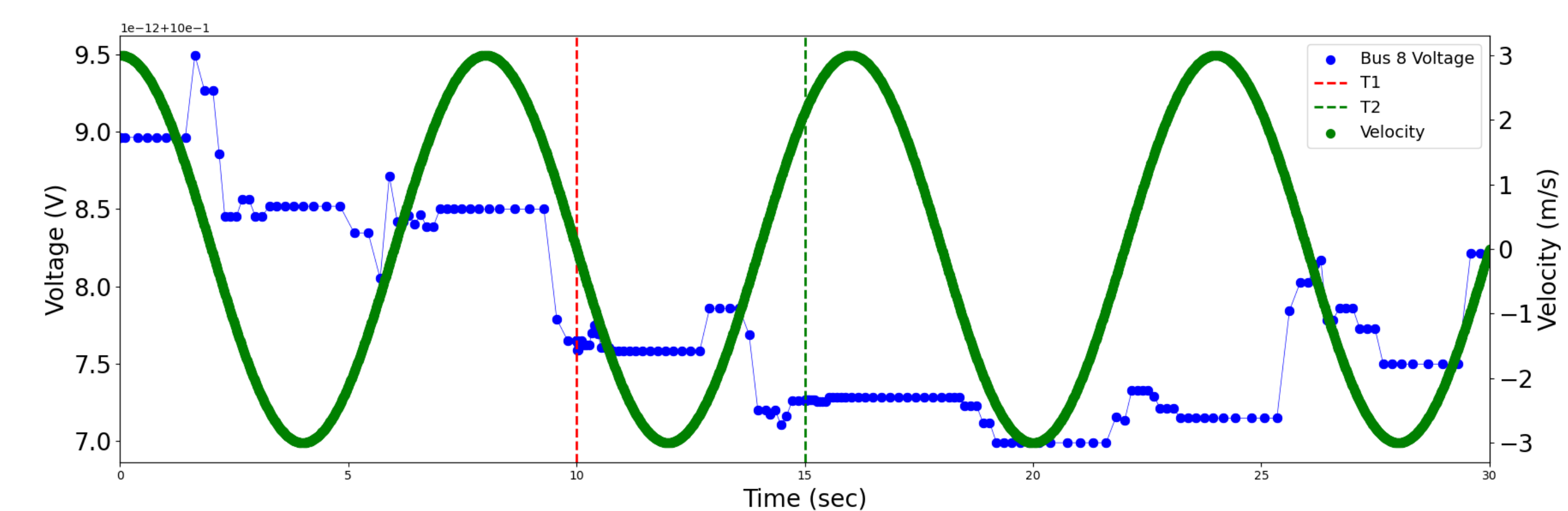


Fig 7. Bus 8 voltage and WEC velocity with active power disruption

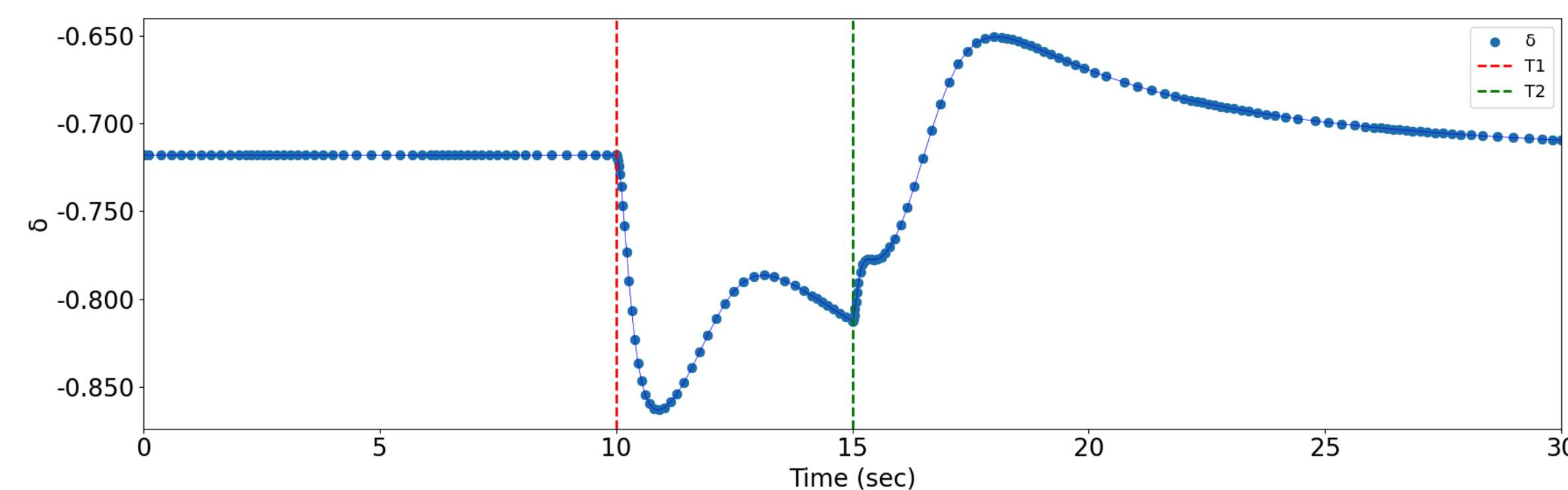


Fig 8. Bus 8  $\delta$  with active power disruption

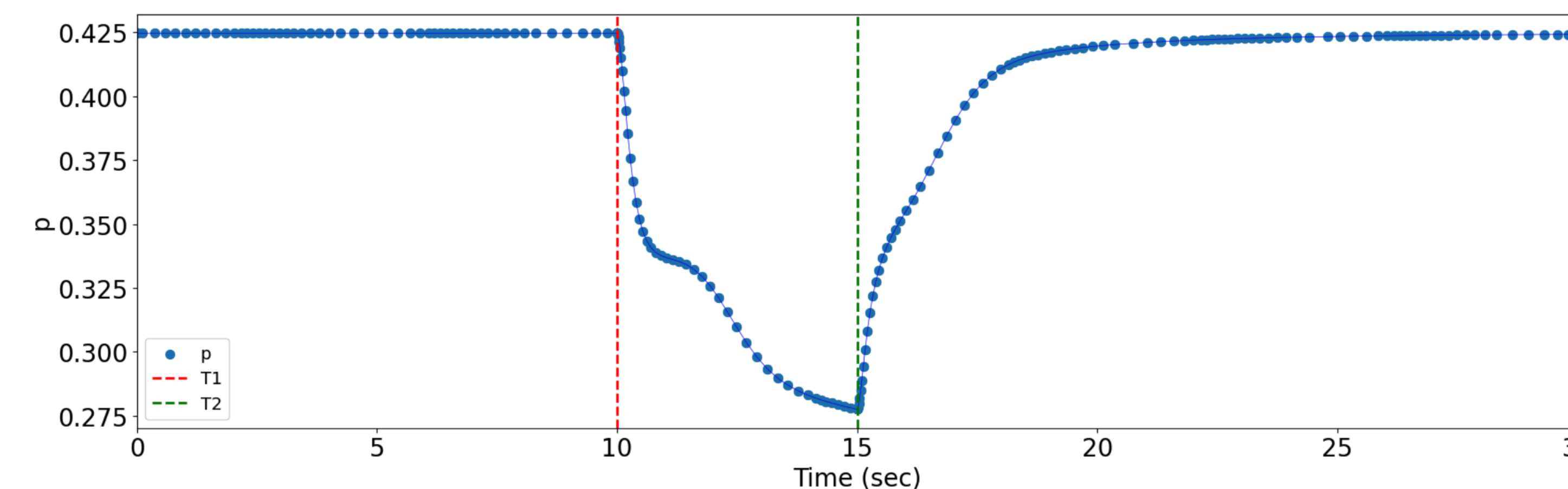


Fig 9. Bus 8 active power with active power disruption