A Voltage Interpolation Method in Inverter Modeling for Fast Electromagnetic Transient Simulations

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CRIEPI Central Research Institute of Electric Power Industry

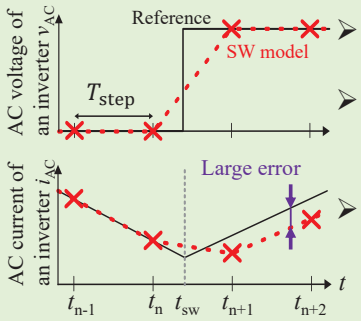
Motivation

- **Target**: Harmonic analyses of the power system with grid-connected inverters
- **Problem**: Large computation time in the electromagnetic transient (EMT) simulations
- **Purpose**: Enabling fast EMT simulations with accurate harmonic components

Approach

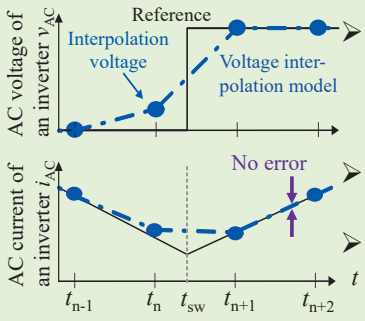
1. Concept of the voltage interpolation method

1.1 Conventional SW model



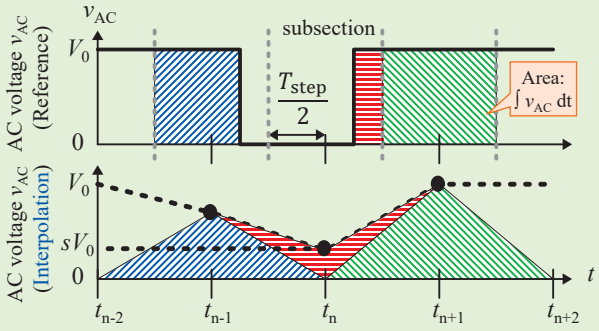
- AC voltage coincides with the reference
- Large simulation time step (T_{step}) causes the error in the ac current
- Requiring small T_{step} for reducing the error

1.2 Proposed voltage interpolation model



- Modified AC voltage at switching instants to make "$\int v_{AC}\,dt$" be equal to the reference
- AC current coincides with the reference
- Enabling to enlarge T_{step} without error

2. How to calculate the interpolation voltage?



- The reference is divided into subsections in each $t_n \pm \frac{T_{step}}{2}$
- The interpolation voltage sV_0 is given to form the same area as the subsection
- Such sV_0 can be calculated as follows:

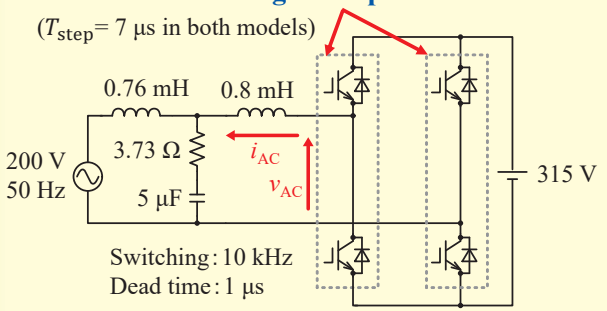
$$sV_0 = V_0\left(\frac{1}{2} + \frac{v^* - v_{carrier}}{kT_{step}}\right),$$

where all parameters are available in the simulation (voltage reference v^*, carrier voltage $v_{carrier}$, carrier inclination k).

Simulation conditions

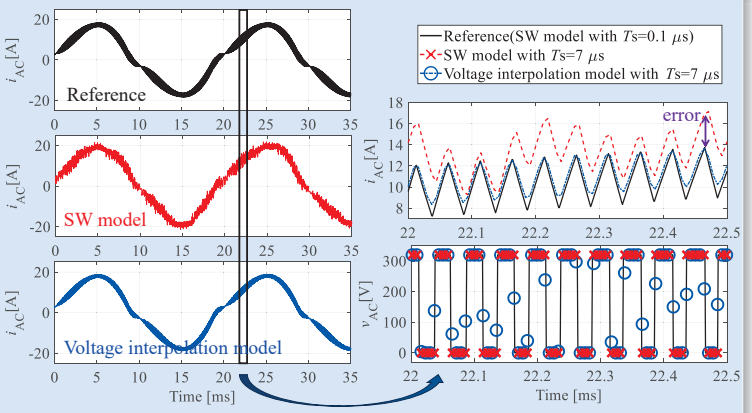
SW model or **voltage interpolation model**

(T_{step}= 7 μs in both models)



Simulation results

1. The simulation results of i_{AC} and v_{AC}



- The voltage interpolation model can accurately simulate the AC current even with a large T_{step}.

2. Comparison of computation times

Model (Simulation time step)	Computation time
SW model (T_{step}=0.1 μs)	100 %
Voltage interpolation model (T_{step}=7 μs)	6.5 %

- The voltage interpolation model can reduce the computation time to 1/15 for achieving the same accuracy as the SW model.

Conclusions

- Proposal of a modeling method of the inverter for fast EMT simulations including harmonic components.
- Simulation results verified that the proposed method can reduce the computation time to 1/15 for achieving the same accuracy as the conventional SW model.