

## **An Introduction to the Simulation Program XTAP for the Analysis of Electromagnetic Transients in Power Systems**

**Taku Noda, Rikido Yonezawa and Yohei Tanaka**  
**Simulation Frontier Group, Energy Innovation Center, CRIEPI**  
**Yokosuka, Kanagawa, Japan**

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### **Abstract**

XTAP, which stands for eXpandable Transient Analysis Program, is a computer program for the waveform-level simulation of power systems. In the field of power system analysis, the waveform-level simulation is often referred to as the electromagnetic transient (EMT) simulation. XTAP is one of the EMT simulation programs. XTAP can be used not only for traditional EMT simulations such as overvoltages, inrush currents and abnormal oscillations occurring in power systems but also for new simulation needs which include assessment of various power quality problems and performance studies of power-electronics converters used in HVDC systems and FACTS devices. Studies related to power-electronics converters used in renewable energy interconnections are also included. XTAP uses accurate and numerically robust algorithms mentioned below and is equipped with a user-friendly graphical interface, comprehensive component and model libraries, practical examples (test cases) and supporting tools. In Japan, all utility companies use XTAP as their standard, and major manufactures, universities and research institutes form a user community.

XTAP has been developed with incorporating recent research results obtained in the last decade. For instance, XTAP uses the two-stage diagonally implicit Runge-Kutta (2S-DIRK) method for the numerical integration of differential equations. It is mathematically guaranteed that the 2S-DIRK method never produces fictitious numerical oscillation due to sudden changes of inductor currents and capacitor voltages unlike the trapezoidal method which has been traditionally used in many programs, and thus, XTAP gives accurate results especially for simulations including power electronics converters. XTAP also incorporates the research results of a robust solution method for nonlinear circuit equations, parallel and efficient sparse matrix manipulation methods using multi-core CPUs, and so on.

XTAP has been and is used for studies related to the following items. *Abnormal Overvoltages and Currents:* lightning, switching and black-start overvoltages, transformer and induction motor/generator inrush currents, ferroresonance, and subsynchronous resonance (SSR). *Power Quality Assessment:* harmonics, flicker, and voltage interruptions/drops/swells. *Power-Electronics Converters:* HVDC systems, FACTS devices, and renewable energy interconnections.

This presentation introduces the program XTAP and its technical aspects mentioned above. Practical applications of XTAP and engineer education aspects are also introduced.

**Note:** This document will be opened to the participants on IERE website before the Workshop and opened to the public afterward.