

U *I* What Are Electromagnetic Transients?

ECE 523
Lecture 19

- Power systems normally in steady-state
 - » Or Quasi-steady-state
 - » Allows use of RMS phasors
- Switching, operations, faults, lightning,
 - » Response frequencies from DC to MHz
 - » Generally dies out rapidly (higher freq.)
 - » Large voltage and currents are possible
 - » RLC response to change in voltage or current

Intro to EMTP simulation

1

Fall 2023

1

U *I* Why Analyze Transients?

ECE 523
Lecture 19

- Power systems operate in sinusoidal steady-state majority of time
- Sudden changes cause large voltage and currents
 - » Including faults and response to clearing faults
- Protection decisions before transients die out → or even based on transients

Intro to EMTP simulation

2

Fall 2023

2

- Output often as time domain waveforms
- Often want instantaneous peak values of $v(t)$ and $i(t)$
 - » Or in some cases energy
 - » Peaks missed with RMS or harmonic solutions

- Predates use of digital computers
 - » Analog computer model
 - » Hybrid: digital controls
- Real-time digital simulators

- Cost limits to small class of problems
 - » Closed loop testing of control hardware

**U
I**

Off-Line Time Domain Simulation

ECE 523
Lecture 19

- Digital computer simulation of transients
- General purpose equation solvers:
MATLAB, MathCAD
- Analog electronic and integrated circuits:
SPICE, Saber
- Not really designed for power system
transients

Intro to EMTP simulation

5

Fall 2023

5

**U
I**

The Electromagnetic Transients Program-EMTP

ECE 523
Lecture 19

- Hermann Dommel, Germany, then BPA
- Numerically solves difference equations
- Fixed versus variable time-step
- EMTP has become an industry standard
(verified models)
- Modules in other power systems programs
- Matlab toolbox

Intro to EMTP simulation

6

Fall 2023

6

- Original version mainly modeled RLC elements switches, ideal sources and lines
- Many extensions and several versions
 - » ATP: Alternate transients program (<http://www.emtp.org>)
 - » EMTP-RV (<http://www.emtp.com>) latest from DCG
 - » EMTDC: student version available free from their web site (<http://www.pscad.com/>)
 - » RTDS: Real time digital simulator (cost)
 - » SimPowerSystems blockset for Matlab

Z

- Outputs are voltage, current, power, and energy versus time
- Control variables are available if controls are modeled
- Can model simple controls using EMTs control models or can interface to FORTRAN (in some cases C or Matlab too)
 - » Programs have internal control modeling
 - » Graphical user interface

8

- ATP is essentially free. A license application needs to be filled out (do not choose student license)
 - » <https://www.atp-empt.org/>
 - » The purpose is to limit access to parties that have participated in “EMTP-Commerce”

- Available for download from ATP distribution sites
- Follow link for ATPDraw for information about the program
 - » Latest versions are version 7.4
 - » File format not backward compatible
 - » <http://www.atpdraw.net/> (ATPDraw only, not ATP itself)
- Get the program and the patch files (update to fix bugs in executable)
- Manual and introduction presentation for download

- Education version available in ECE labs
- Free Student Edition (15 node limit)
 - » Go to: <http://www.pscad.com/>
 - » Create account and get set up to download
 - Download the Program itself
 - Includes free Fortran Compiler
 - Need unless you have compatible one installed
- Website also has tutorials
- Remote access on UI computers

- Available in ECE labs
- Remotely available on University of Idaho computers
- Tutorials available at <https://www.emtp-software.com/>

U *I* Learning ATPDraw/ATP or PSCAD/EMTDC

ECE 523
Lecture 19

- Can provide access to lectures from other classes → especially for ATPdraw
- You can use the examples from course web page for the anything we do in this class.

Intro to EMTP simulation

13

Fall 2023

13

U *I* Validation of Models...

ECE 523
Lecture 19

- Graphical user interfaces have made transients programs much easier to use
- It is very easy to get simulation results
- But it is critical to be able to verify that the results are correct
- First step is validating the system model

Intro to EMTP simulation

14

Fall 2023

14

- Need to have a basic idea of what the transient response should look like
- Test your system with some very predictable cases
- Start from steady-state operating point
- Understanding behavior will be one of the focuses of this course