



**Electric Power & Power Electronics Institute**  
**Department of Electrical Engineering**  
**Texas A&M University**  
**College Station, TX 77843-3128**

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TEXAS 77843  
PERMIT NO. 215

*Attend the course to gain education  
and experience in using advanced  
hardware and software tools for  
new relay testing methodology.*



Electric Power and  
Power Electronics Institute

**2002**

**Protective Relay Testing  
Using EMTP and Digital Simulators**

**Short Course**

May 8 - 10, 2002

College Station, Texas

Texas A&M University  
Department of Electrical Engineering  
College Station, Texas 77843-3128  
USA

## Introduction

This course offers the unique opportunity to learn all the steps in using advanced software and hardware tools to perform transient testing of protective relays.

The course starts with simulating electromagnetic transients using the ElectroMagnetic Transient Program (EMTP). The relay design part of the course provides insides of modern digital relays and helps in understanding the behavior of relays under transient test. Digital simulators part is focusing on the requirements, hardware and related software tools. The testing practices and methodologies using transient modeling and digital simulators are presented.

Exceptional laboratory resources are available at TAMU including personal computers, digital simulators and variety of digital relays to be used in the hands-on part of this short course.

## Unique Features/Benefits

- Access to Texas A&M University's laboratory equipped with electromagnetic transient program workstations, protective relays, and a two-terminal digital simulator for relay testing
- Hands-on experience in power system modeling as well as relay testing using digital simulators
- Education on signal and logic processing in microprocessor-based relays, and relay testing methodologies
- Experience in assessing performance characteristics of digital simulators
- Experience in testing and evaluating protective relays using transients programs and digital simulators

## Who Should Attend

- Engineers responsible for utility protection, control and planning
- Engineers responsible for relay developments and evaluation
- Personnel in charge of relay and substation maintenance and testing
- Developers & users of test equipment
- Engineering consultants
- University faculty and advanced graduate students

## Instructors

**Ali Abur**, professor of electrical engineering, Texas A&M University. Abur's teaching and research interests are in power system modeling and simulation, power quality assessment, and optimization methods applied to power system problems. He has conducted research projects related to digital simulators for relay testing, and to power quality assessment computer tools.

**Bogdan Kasztenny**, Senior Application/Invention Engineer, GE Power Management. Dr. Kasztenny was a visiting assistant professor in electrical engineering at Texas A&M. His professional interests are in protective relaying, digital signal processing and artificial intelligence methods applied to power system monitoring, control and protection. He has conducted design projects related to digital protection of power transformers and lines.

**Mladen Kezunovic**, Eugene E. Webb professor of electrical engineering and director of Electric Power & Power Electronics Institute, Texas A&M. Kezunovic conducted several research and development projects related to digital simulators and simulation methods for relay testing. He is an IEEE Fellow and PE in the State of Texas.

**Donald R. Sevcik**, Consulting Engineer, Substation Projects Section, Reliant Energy HL &P. Sevcik has extensive knowledge in protective relaying application/settings calculation, modeling/short circuit calculations, electrical power equipment application/specification, substation configuration/layout design, substation project engineering coordination, and power system disturbance analysis.

## Course Descriptions

### Intro: What's New in Relay Testing?

M. Kezunovic, A. Abur

- Course objectives and outline
- Protective relaying testing practices
- Introduction to transient simulations
- Guidelines and simulation methods

### Simulation Programs - A. Abur

- Electromagnetic transient programs
- Data requirements
- Input interface
- Output processing

### Transmission Line Modeling

A. Abur

- Transmission line parameter calculations
- Traveling waves
- Multi-phase models, modal analysis
- Discrete time models for transients simulation
- Distributed, constant parameter models
- Frequency dependent models
- Source models and network equivalent modeling

### Transformer Modeling A. Abur

- Nonlinear elements: data requirements
- Multi-phase, multi winding transformer models
- Saturation and inrush
- Instrument transformers: CTs & CCVTs

## Laboratory Hands-on Facilities

- 16 PCs in the new Power System Laboratory,
- Digital simulators capable of replaying DFR files and waveforms obtained by simulating power system faults
- Power amplifiers capable of supplying up to 100A and 300V RMS currents and voltages for testing actual relays
- A wide selection of protective relays by major manufacturers to be used in testing
- State-of-the-art audio-visual equipment.

## Computer Laboratory Exercises

A. Abur

- Simple switching transients
- Simulation of faults: effects of fault resistance, type, inception angle, location
- Long and short lines
- Mutually coupled lines
- Series capacitors and MOVs
- Network equivalents

### Digital Relaying I

M. Kezunovic, B. Kasztenny

- Microprocessor distance relays
- Microprocessor relay hardware
- Data sampling, filtering and multiplexing
- A/D conversion, data storing and processing

### Digital Relaying II

M. Kezunovic, B. Kasztenny

- Microprocessor relay software
- Fault detection and classification
- Digital algorithms for impedance computation

### Digital Simulators - M. Kezunovic

- Simulator configuration
- Relay testing methodology
- Simulator requirements

### Laboratory Exercises: Relay Testing Using Digital Simulators

D.R. Sevoik, M. Kezunovic

- Test cases
- Relay design testing
- Relay application testing
- One and two terminal testing

## Instructional Materials

- Detailed course notes
- EMTP input data files with examples from the course and extra cases for the follow-up self-studies
- MATLAB programs accompanying the relay design lectures and extra examples for the follow-up self-studies
- Printed materials on hardware and software tools for digital simulators
- Documented test cases for digital simulator exercises

TIMES	DAY 1	DAY 2	DAY 3	<b>PROTECTIVE RELAY TESTING SCHEDULE</b>
8:00	Introduction	Computer Laboratory Exercises	Laboratory Exercises: Relay Testing using Digital Simulators	
9:00	Simulation Programs			
10:00	Transmission Line Modeling	Digital Relaying I		
Noon	Lunch	Lunch	Adjourn	
1:30	Transmission Line Modeling (continued)	Digital Relaying II		
2:30				
3:30	Transformer Modeling	Digital Simulators		
4:00				
5:30	Adjourn	Adjourn		

### TRAVEL, HOTEL, AND PARKING INFORMATION

American and Continental Airlines serve College Station through Dallas and Houston. College Station is located 90 miles north of Houston Intercontinental Airport on Texas Highway 6 via Interstate Highway 45 and State Highway 105.

A partial list of local hotels is provided below. Make reservations early. Hotels marked with (\*) asterisk may provide transportation to campus *if requested at check-in*.

Parking fees on campus may be paid in two ways: (1) in advance by mail with registration (least cost) and (2) on a daily basis at the parking garage on a first-come-first-serve basis.

On-Campus Lodging may be obtained by calling the Memorial Student Center, (979) 845-8908.

#### Off-Campus Lodging:

Best Western Inn at Chimney Hill, 901 University Dr. (979) 260-9150  
Days Inn College Station, 2514 Texas Ave. S. (979) 696-6988  
Fairfield Inn, 4613 S. Texas Ave. (979) 268-1552  
Hampton Inn\*, 320 Texas Ave. S. (979) 846-0184  
Hilton Hotel \*, 801 University Dr. (979) 693-7500  
Holiday Inn-College Station, 1503 Texas Ave S. (979) 693-1736  
Holiday Inn Express, 1203 University Dr. East (979) 846-8700  
KIVA\*, 104 Texas Ave. S. (979) 846-7333  
LaQuinta, 607 Texas Ave. S. (979) 696-7777  
Quality Suites, 1010 University Dr. East (979) 695-9500  
Ramada Inn, 1502 Texas Ave. S. (979) 693-9891  
Super 8 Motel, 301 Texas Ave. (979) 846-8800  
Towneplace Suites by Marriott, 1300 University Dr. E. (979) 260-8500

## REGISTRATION FORM

### Electric Power & Power Electronics Institute Short Course

Dept. of Electrical Engineering  
Texas A&M University  
College Station, Texas 77843-3128

Tel: (979) 845-1814  
Fax: (979) 845-9887  
E-mail: nancy@ee.tamu.edu

Name \_\_\_\_\_

(Last)

(First/Middle)

Organization \_\_\_\_\_

Job Title \_\_\_\_\_

Mail Address \_\_\_\_\_

\_\_\_\_\_

Telephone \_\_\_\_\_ Fax \_\_\_\_\_

E-mail \_\_\_\_\_

#### REGISTRATION FEE \*\*

One Person	\$ 1,000.00
CEU Processing Fee	\$ 25.00
(SS# _____)	
On-Campus Parking	
\$4 per day x ___ days	\$ _____

TOTAL \$ \_\_\_\_\_

\*\* Discounts available for EPPEI members.  
Inquire about discounts & membership.

Mail registration form with payment to:  
EPPEI, Texas A&M University  
ATTN: Nancy Reichart  
Dept. of Electrical Engineering  
College Station, TX 77843-3128 USA

#### PAYMENT

Company Check (U.S. Dollars) \$ \_\_\_\_\_

Credit Card\* (circle one)

Master Card    Visa    AmEx

Name as it appears on the card: (Please print)

\_\_\_\_\_

Card # \_\_\_\_\_

Exp. Date \_\_\_\_\_

Signature \_\_\_\_\_

\*Bank surcharge added for credit card payments.

**Continuing Education Units (CEU)** are available upon request by marking the appropriate box on the registration form and submitting the fee. Completing the course will earn 1.4 CEUs.

**Cancellation Policy** Guaranteed registration deadline is April 29. After April 29, registration is on a first-come-first-serve basis only. Registration fees will be refunded, less a cancellation fee of \$100, if written cancellation request is received on or before May 3. TAMU reserves the right to cancel the course, if necessary, due to low registration before May 3 and will provide full refund of paid registration fees.

#### Internet Information

##### **This Course:**

<http://ee.tamu.edu/~eppe/ShortCourses/scs1.htm>

##### **Other Courses:**

<http://ee.tamu.edu/~eppe/ShortCourses/services.htm>

##### **EPPEI Membership/Discounts:**

<http://ee.tamu.edu/~eppe/summary.htm>