

# Department of Electrical and Computer Engineering Electric Power and Power Electronics Institute

---

## 3-Day Short Course

### **PROTECTIVE RELAY TESTING USING EMTP AND DIGITAL SIMULATORS**

Prof. M. Kezunovic<sup>\*</sup>, Prof. A. Abur<sup>\*</sup>, D. R. Sevcik<sup>\*\*</sup>, and B. Kasztenny<sup>\*\*\*</sup>

<sup>\*</sup> Department of Electrical and Computer Engineering, Texas A&M University

<sup>\*\*</sup> Reliant Energy HL&P

<sup>\*\*\*</sup> GE Power Management

#### **Summary**

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.

#### **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

#### **Unique features and benefits**

- Access to Texas A&M University 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

#### **Contents**

##### *Day 1*

##### **SECTION I. Introduction**

**PRESENTERS: M. Kezunovic and A. Abur**

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

## **SECTION II. Simulation programs**

**PRESENTER: A. Abur**

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

## **SECTION III. Transmission line modeling**

**PRESENTER: 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 equivalencing

## **SECTION IV. Transformer modeling**

**PRESENTER: A. Abur**

- Nonlinear elements: data requirements
- Multi-phase, multi winding transformer models
- Saturation and inrush
- Instrument transformers: CT's and CCVT's

## ***Day 2***

### **SECTION I. Computer laboratory exercises**

**PRESENTER: 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 MOV's
- Network equivalents

### **SECTION II. Protective relaying I**

**PRESENTERS: M. Kezunovic and B. Kasztenny**

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

### **SECTION III. Protective relaying II**

**PRESENTERS: M. Kezunovic and B. Kasztenny**

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

**SECTION IV. Digital simulators**

**PRESENTER: M. Kezunovic**

- Simulator configuration
- Relay testing methodology
- Simulator requirements

***Day 3***

**SECTION I. Laboratory exercises: Relay testing**

**PRESENTER: D. R. Sevcik and M. Kezunovic**

- Test cases
- Relay design testing
- Relay application testing
- One terminal testing
- Two terminal testing