

33RD ANNUAL

HANDS-ON Relay School

MARCH 14-18, 2016



**WASHINGTON STATE UNIVERSITY
PULLMAN, WASHINGTON**

SPONSORED BY:

Western Energy Institute | Washington State University

ONE WEEK FOR ONLY \$650

Applications Accepted November 1, 2015 – January 25, 2016



Conference Management

WASHINGTON STATE UNIVERSITY

33RD ANNUAL

HANDS-ON Relay School

“ This program is an incredible resource. All the instructors display great passion for the industry and the desire to pass on knowledge. ”

“ Nowhere else can you learn this much in one week. ”

“ The structure of taking senior and experienced technicians and letting them teach, walk thru relays, and pass that experience on to upcoming technicians. What an outstanding concept. ”

“ The school provides excellent hands on training with equipment that I am directly exposed to daily and the necessary theory to provide a strong understanding of their protection and functionality. ”

WesternEnergy
INSTITUTE



Conference Management

WASHINGTON STATE UNIVERSITY

OBJECTIVES OF THE HANDS-ON RELAY SCHOOL

The Hands-On Relay School is a professional development short course to train protective relay technicians, electrical/power plant technicians, engineers, and protective relay test specialists.

Students are enrolled in one of seven tracks for the duration of the school.

- Basic
- Distribution
- Transmission
- Generation
- Electromechanical
- Automated Relay Testing
- Theory

Students participating in these tracks will:

- Become familiar with manual or automated test methods for a variety of protective relays and test equipment.
- Gain valuable knowledge relating to relay applications and operating characteristics.
- Exchange ideas and resolve problems in an open forum.
- Learn preventative and corrective maintenance methods.

Application

School enrollment is limited, and priority is given to organizations providing Lab Facilitators, Lecturers, Steering Committee support, and Western Energy Institute member utilities. Refer to important application and enrollment procedures at the end of this brochure.

Call for Lab Facilitators

If you are an experienced relay technician who is willing to share your knowledge with others, you can attend the Hands-On Relay School as a lab facilitator. Lab facilitators work with groups of three students in the hands-on labs testing relays and may attend all classroom lectures and school activities. Lab facilitators are not required to pay the application fee and their company receives priority points for students applying for the school. If you are interested, contact WSU Conference Management at **800-942-4978** or **509-335-3530**.

BASIC TRACK

This track is for those students who wish to focus on the calibration, maintenance, testing, and understanding of basic relays. The selection of relays may include overcurrent, differential, distance, reclosing, voltage, or frequency relays. This track is an excellent choice for beginning technicians. [48 students maximum]

Students in this track will:

- Attend the Introduction to System Protection lecture series.
- Choose four Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Wire an overcurrent and a reclosing relay to a breaker simulator to test and troubleshoot an entire protection circuit.
- Perform hands-on testing in the lab on the following relays:

ABB: CO, HU

Basler: BE1-79A, BE1-81O/U

GE: CEY51, JBCG

SEL: 587

..... Introduction to System Protection Lecture Series

This lecture series is for beginning relay technicians, newcomers to the relaying field, or anyone who needs the basics. We start with the very basics of relaying to provide a foundation of knowledge upon which to build. The closest thing to “Relaying for Dummies” that Hands-On Relay School has to offer! Taught by experienced system protection personnel, this lecture series will be presented on **Monday only** from **7:45AM – 3:00PM**.

Topics include:

- Introduction to Protection Basics and Terminology
Brent Carper, Relay Application Innovation
- Introduction to Phasors Including Phasor Math
Ron Alexander, Bonneville Power Administration
- Print Reading and Lessons Learned from the Field
Paul Luther, Puget Sound Energy

RELAY SCHOOL

DISTRIBUTION TRACK

This track is for those students who wish to focus on the testing and understanding of multifunction microprocessor relays and recloser controllers used for distribution protection. The selection of relays may include overcurrent, transformer differential, reclosing, synch-check, and frequency protection.

[18 students maximum] [Laptop Computer Required]

Students in this track will:

- Attend the Distribution Overview lecture.
- Choose six Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

ABB: REF615

Basler: BE1-11F

Beckwith: M3311A

Cooper: Form 6

SEL: 751A, 787

Distribution Protection Overview Lecture

Kevin Damron, Avista, Spokane, WA

This lecture will review fundamental principles of distribution system protection, including IEEE device designations, fault current calculations, coordination of overcurrent protection, and reclosing schemes.



TRANSMISSION TRACK

This track features both electromechanical and microprocessor-based multi-function relays used for protection of transmission equipment, including distance and line current differential protection.

[24 students maximum] [Laptop Computer Required]

Students in this track will:

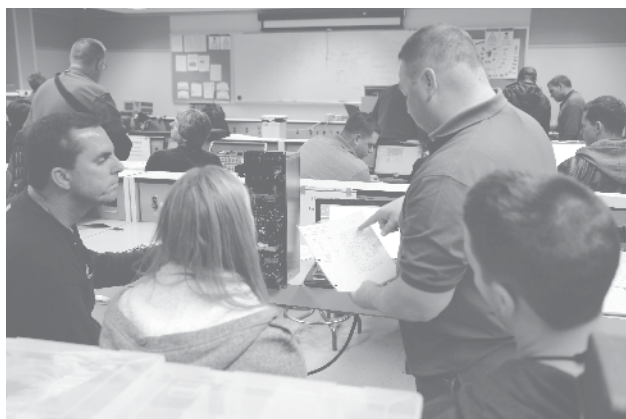
- Attend the Transmission Overview lecture.
- Choose six Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

ABB:	IRD9, KD10
GE:	L90
RFL:	GARD 8K
SEL:	411L, 487E, 587Z

.....
Transmission Protection Overview Lecture

Normann Fischer, Schweitzer Engineering Laboratories Inc

This lecture will review fundamental principles of transmission line protection. Concepts of distance protection, directional overcurrent, line differential, and pilot protection schemes will be discussed.



RELAY SCHOOL

GENERATION TRACK

This track features electromechanical and multifunction microprocessor relays used for transformer and generator differential, over-excitation, stator ground, reverse power, synch-check, negative sequence, and loss of field protection of generators.

[24 students maximum] [Laptop Computer Required]

Students in this track will:

- Attend the Generation Protection Overview lecture.
- Choose six Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

ABB:	KLF
Beckwith:	3425A
GE:	CEX57/GSY51
SEL:	700G
Siemens:	7UM621

..... **Generation Protection Theory and Application Overview Lecture**

*Wayne Hartmann & Jon Grooters, Beckwith Electric,
Largo, FL & Denver, CO*

This lecture will review fundamental principles of generation protection theory and application with a focus on industry standards and best practices.



ELECTROMECHANICAL TRACK

This track focuses exclusively on electromechanical relays used for line, bus, transformer, or generator protection. More hands-on effort is spent on troubleshooting relay problems, calibrating relays, adjustment techniques, and verifying results. [12 students maximum]

Prerequisite: Basic track or related experience.

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview lecture.
- Choose six Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:
ABB: IRD9, KD10, KLF-I
GE: BDD, CEB52, GCX51, INC77, PVD



RELAY SCHOOL

AUTOMATED TESTING TRACK

This track is intended for technicians who already understand relay operating principals, have experience in manual testing, and are ready to learn automated testing methods. [student maximum varies]

Note: This track is NOT recommended for those relay technicians who are just starting out. The emphasis of this track is on the test equipment and software, not on the relays. The hands-on labs are taught by the test equipment and software manufacturers, not by the relay manufacturers.

Prerequisite: Experience in manual relay testing and computer use. A laptop computer will be used to communicate with the relays and/or the test set. All students must have administrative rights to their laptop, with the appropriate software pre-loaded.

Students in this track will:

- Attend an Overview Lecture provided by the test equipment or software manufacturer.
- Choose six Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab using one of the following testing software programs:

Doble

Enoserv RTS

Megger AVTS

Omicron

Noram SMC

Some test software vendors will offer both a Beginning and an Advanced section, depending on enrollment and skill level of the students. Beginning automated testing still requires a prerequisite understanding of manual testing.

THEORY TRACK

This track provides more in-depth training on application and theory of operation of protection systems utilized in the power system. This track does not normally include any hands-on training with relays, but will include some hands-on use of your laptop. [Laptop computer required]

Emphasis this year will be on Generation concepts and applications.

Note: The theory track is for the journeyman relay technician and relay engineers. It is NOT recommended for those relay technicians who are just starting out. Instructors and lecturers for the theory track are considered to be experts in their field. Students are expected to bring their own laptop PC with administrative privileges over the operating system sufficient to load vendor software.

Students in this track will:

- Attend the Generation Overview lecture.
- Choose six Concurrent Open Lectures to attend.
- Attend the Monday and Tuesday PM and all day Wednesday and Thursday Lectures.
- Attend the Friday Feature Lecture Presentations.
- Attend the advanced topic lectures throughout the week, as follows.

Generator Protection

Roy Moxley, Siemens

Political and economic factors have been driving the introduction of new generation sources in the power grid. This session will present the characteristics of a number of these sources and how they impact protection. Included will be: wind with its different types of machines; solar and small synchronous media. Impacts discussed will include dynamic performance, reclosing considerations and protection options.

Generator Auxiliaries

Zach Behrens, MWH

Protective relays are only a portion of what is necessary to keep generators operating and healthy. This lecture will provide students with an overview of synchronous generator auxiliary systems. Areas of study include governors, exciters, machine condition monitoring, cooling systems, lube systems, and more.

RELAY SCHOOL

THEORY TRACK

Power Quality

John Schaad, Bonneville Power Administration

This course covers the basic concepts, terminology, relevant standards, effects on customers' equipment, and examples of Power Quality disturbances.

Generator Protection Theory

Wayne Hartmann, Jon Grooters, Steve Turner, Beckwith Electric

This session provides fundamental information on generator construction, connection, and grounding. They influence ground fault protection methodology. A review of the latest IEEE Guide for Generator Protection (C37.102) provides an overall baseline into the various recommended protections. Explanations of how they function to protect the generator against internal faults, system faults, and generator and system abnormal operation. Upgrade considerations, NERC issues with event reporting and use of visualization tools for setting, commissioning, test and event analysis. Testing methodology and demonstration for ground fault protections is explained and demonstrated. In particular, testing injection-based protections including 64S 100% stator ground fault and 64F/B rotor ground fault/brush lift are detailed.

Prime Movers, Synchronous Generator Construction and Protection

Rogério Scharlach, Schweitzer Engineering Laboratories Inc.

This course covers the basic principles of the most common primer movers: gas, steam, hydraulic, and wind turbines. It discusses the constructive aspects of a synchronous generator and provides the students with a comprehensive introduction to synchronous generator protection.

CONCURRENT OPEN LECTURES

The Hands-On Relay School offers twelve lectures on a wide range of topics relevant to the trade. Each lecture is one hour long and given a total of three times. Students can attend up to six lectures of their choosing.

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Breaker Failure Protection

Brent Carper, Relay Application Innovation Inc.

This lecture will review different types of breaker failure protection systems, relays, and logic, including general considerations for determining relay pickup and timing settings.

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CT Testing & Theory

Jay Anderson, OMICRON

Current measurement is integral to almost all protection schemes on the power system and, since direct measurement is not an option in many cases, current transformers must be used. Lecture will cover the operating principles of how current transformers work (including polarity, ratio, and excitation) as well as how to test them to ensure proper performance and accuracy.

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End to End Testing

Rick Asche, Portland General Electric

Communication assisted protection schemes require time synchronized fault current simulations to properly test the entire scheme. This lecture will present an overview of the procedure for test preparation and organization, equipment requirements, fault selection, test execution, and the performance criteria for commissioning a new or existing transmission protection scheme. Application to other protection schemes will also be discussed.

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Fault Analysis for Relay Technicians

Ken Workman, Schweitzer Engineering Laboratories Inc.

Event reports continue to be an invaluable feature in microprocessor-based relays. Some events are relatively straightforward to analyze, and others require experience and considerable knowledge of the power system and protective relay system in order to find the root cause. This session provides an outline of the event analysis process, several real-world event examples, time to evaluate them, and solutions.

RELAY SCHOOL

CONCURRENT OPEN LECTURES

Generator Auxiliary Systems

Zach Behrens, MWH

Protective relays are only a portion of what is necessary to keep generators operating and healthy. This lecture will provide students with an overview of synchronous generator auxiliary systems. Areas of study include governors, exciters, machine condition monitoring, cooling systems, lube systems, and more.

Note *If you are a student in the Theory Track, please do not attend this lecture as this material plus more on generator auxiliaries will be covered in the Theory Track.*

Mho Testing Techniques & Math

Rodger Allen, ACS Professional Staffing

Learn or revisit the considerations to take, and the math behind, selecting the voltages and currents to test the characteristic of phase to phase and 3 phase mho distance units effectively and efficiently. Students will participate in phase to phase voltage and current calculations. Test equipment and relays will demonstrate the success.

Negative Sequence—How to Use It

Greg Smelich, Schweitzer Engineering Laboratories Inc.

With the advent of microprocessor relays, access to sequence network values in real time is now common place. How do we use these qualities for better and faster protection of the power system? Protection schemes that use negative sequence will be discussed and include differential, overcurrent, and directional elements.

Phasor Diagrams

Ron Alexander, Bonneville Power Administration

Phasors are the universal language of system protection technicians and engineers. This lecture emphasizes the need for a basic knowledge of phasor diagrams and their use in understanding the power system. Topics include load flow phasor analysis, fault phasor analysis, and using phasors to determine the phase angle across delta-wye transformers banks.

CONCURRENT OPEN LECTURES

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Remedial Action Schemes

Brant Heap, Salt River Project

Remedial Action Schemes, otherwise known as Special Protection Systems (SPS), are becoming more common among utilities. This presentation will provide an overview of why these schemes are necessary, cover different types of RAS schemes, and discuss design criteria to help understand these sometimes complicated systems.

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Substation Commissioning

Paul Luther, Puget Sound Energy

A discussion on substation commissioning, from small device repair to full green field substation projects. The focus will be on developing a plan to completely commission equipment with a check and balance system that gives the technician confidence that the job was done correctly. Example checklists and worksheets will be handed out to students.

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Symmetrical Components 1

Stephen Marx, Bonneville Power Administration

Basic principles of symmetrical components with explanation of phasors, per unit system, and symmetrical component equations using sequence networks. *Suggested prerequisite for Symmetrical Component 2 class.*

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Symmetrical Components 2

Stephen Marx, Bonneville Power Administration

Analysis of power system elements with symmetrical components sequence network and network connections for each power system fault types. Samples of protective relay applications using symmetrical component method. *Suggest attending Symmetrical Components 1 lecture as a prerequisite.*

RELAY SCHOOL

FRIDAY FEATURE PRESENTATIONS

Power System Operations

Rich Hydzyk, Avista Utilities

What does it take to drive the power system? Keeping substation voltages within schedule, preventing lines from overloading, and anticipating the next outage can be a difficult task. Lecture will cover how system operators control volt/Vars, utilize Automatic Generation Control (AGC) to balance load to generation in real time, and maintain overall stability of the power system.

Traveling Waves for Fault Location and Protection

Venkat Mynam, Schweitzer Engineering Laboratories Inc.

Lecture will discuss fault location methods using traveling waves, field data shall be used to demonstrate the exceptional accuracy at the fault location. Traveling waves can also be used to provide ultra high speed line protection. This lecture will discuss traveling basic differential and directional line detection elements.



2016 SCHEDULE AT A GLANCE

The Hands-On Relay School is held on the Washington State University campus in Pullman, Washington. Evening events and Sunday check-in registration are held at the University Inn Best Western in Moscow, Idaho, or as noted.

Sunday, March 13

3:00-6:00 PM	Facilitator Lab Set Up (EE/ME 44)
5:30-7:30 PM	Registration & Reception (University Inn)
7:00-8:00 PM	Lab Facilitator Meeting (University Inn)

Monday, March 14

6:45-7:30 AM	Registration
7:30 AM-Noon	Opening Announcements Overview Lectures Concurrent Open Lectures Introduction to System Protection Lecture Series
1:00-5:00 PM	Hands-on Lab Instruction
5:00 PM	Optional Social Get Together at Birch & Barley Restaurant

Tuesday, March 15

7:30 AM-Noon	Concurrent Open Lectures
1:00-5:00 PM	Hands-on Lab Instruction
6:30-9:00 PM	Suppliers Showcase (University Inn)

Wednesday, March 16

7:30 AM -Noon	Hands-on Lab Instruction
1:00-5:00 PM	Hands-on Lab Instruction
6:30-9:00 PM	Banquet & Entertainment (University Inn)

Thursday, March 17

7:30 AM-Noon	Hands-on Lab Instruction
1:00-5:00 PM	Hands-on Lab Instruction

Friday, March 18

7:30-8:00 AM	Closing Remarks
8:00-11:30 AM	Friday Feature Presentations

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SPONSORS



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STEERING COMMITTEE

Cliff Harris *Committee Chair, Idaho Power Company*

Rodger Allen *ACS Professional Staffing*

Rick Asche *Portland General Electric*

James Cornett *Salt River Project*

Kurt Dobin *PacifiCorp*

Chris Gallacher *Avista Utilities*

Wilfredo Guevara *San Diego Gas & Electric*

Scott Hanson *Washington State University*

Tamara Kirk *Washington State University*

Stephen Marx *Bonneville Power Administration*

Darcy Nutter *Western Energy Institute*

Pat Phillips *Seattle City Light*

Travis Rider *Pacific Gas & Electric Company*

Greg Sharpes *Avista Utilities*

Randy Turnley *Puget Sound Energy*

Bill Unbehaun *Tacoma Power*

Darryl Walker *Puget Sound Energy*

Louis Wright *Bonneville Power Administration*

Diana Zoren *Western Energy Institute*

CONTRIBUTING ORGANIZATIONS

The Hands-On Relay School Steering Committee gratefully acknowledges the following organizations for their generous contributions of equipment and support personnel.

ABB Power T&D Company Inc.	OMICRON
ACS Professional Staffing	PacifiCorp
Avista Utilities	Pacific Gas & Electric
Basler Electric Company	Peak Measure
Beckwith Electric Company	Pegasus-Global
Benton County PUD	Portland General Electric
Bonneville Power Administration	Power Testing and Energization Inc.
BSC Engineered Systems	PPL Montana
Central Electric Cooperative Inc.	Puget Sound Energy
Central Lincoln PUD	Relay Application Innovation
Chelan County PUD	RFL Electronics Inc.
City of Richland	RuggedCom
Clark Public Utilities	Sacramento Municipal Utility District
Cooper Power Systems	Salt River Project
Doble Engineering Company	San Diego Gas & Electric
Douglas County PUD	Schneider Electric
Emerson	Schweitzer Engineering Laboratories
Energy Northwest	Seattle City Light
ENOSERV	Siemens
Eugene Water & Electric	SMC Inc.
Franklin County PUD	Snohomish County PUD
GE Digital Energy – Multilin	Tacoma Power
Grant County PUD	Tri-State G&T
Idaho Power Company	U.S. Army Corps of Engineers
Manta Test Systems	U.S. Bureau of Reclamation
Matanuska Electric Association	Washington State University
Megger	Western Area Power Administration
MWH	Western Energy Institute
NorthWestern Energy	
NV Energy	

RELAY SCHOOL

SCHOOL INFORMATION

..... Application Process and Fees

- Application is online at **<http://cm.wsu.edu/hrs>**.
- School fee of \$650 includes electronic copies of lecture notes, Sunday night reception, Tuesday night Vendor Showcase, Wednesday night banquet meal, break refreshments, and parking fees.
- Priority is given to utilities providing lab facilitators, lecturers, steering committee support, and Western Energy Institute member utilities, if the application is received by January 25, 2016. Remaining slots will be filled on a first-come, first-served basis.
- Applicants select which track they wish to attend in order of preference. Every effort will be made to place students into their preferred track, but track placement is by availability and subject to the priorities as described above. Many tracks will fill up and students may not be able to get their preferred track. If we are unable to place you in a track you have selected, or in an acceptable substitute track, your full application fee will be refunded.
- Students will be notified in writing no later than February 5, 2016, of their acceptance into the school and track placement. You are not accepted to attend unless you receive the confirmation of acceptance from WSU.
- Questions? Call **800-942-4978** or **509-335-3530** or email us at **tlkirk@wsu.edu**. Visit our website at **conferences.wsu.edu**.

SCHOOL INFORMATION

..... **Accommodations and Travel**

Please make your own travel and hotel reservations once you have received registration confirmation. The Pullman/Moscow Airport is served by Alaska/Horizon Airlines. Spokane International Airport is 80 miles north of Pullman. Holiday Inn Express (509-334-4437) in Pullman, and the University Inn (208-882-0550) in Moscow, Idaho, have rooms blocked for this event and all will provide local transportation upon request.

..... **Cancellation Policy**

Your complete application fee will be refunded if WSU receives your written cancellation notice by **February 22, 2016**. Cancellations made after February 22 are subject to a processing fee of \$325. Students who do not attend and have not cancelled by March 11th are responsible for the full application fee. Substitutions may be made at any time.

..... **Program Changes and Cancellations**

WSU reserves the right to make changes in programs or speakers or to cancel programs if enrollment criteria are not met. In the unlikely event that this school is cancelled, Washington State University's liability is limited to refund of registration fees. If we are unable to place you in a track you have selected or an acceptable substitute track, your full registration will be refunded.

RELAY SCHOOL

SCHOOL INFORMATION

Americans with Disabilities Act

Accommodations for individuals who qualify under the Americans with Disabilities Act are available upon request. Please contact us at least ten days before the school at **800-942-4978** or **509-335-3530**, email **wsuconf@wsu.edu**

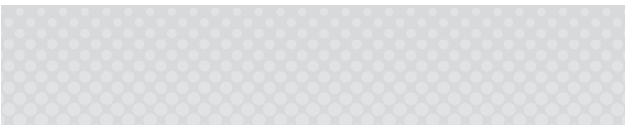
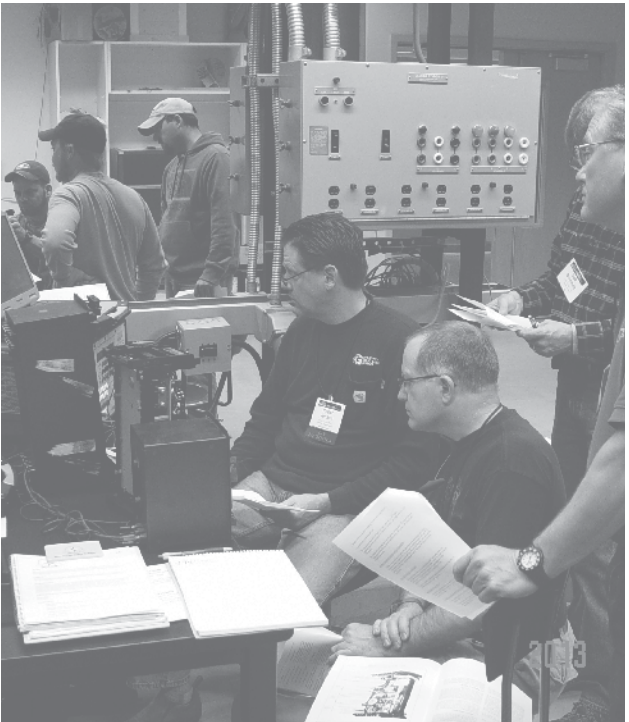
Continuing Education Units (CEUs)

CEUs are available to participants who complete a CEU enrollment form prior to the start of the school and satisfactorily complete the requirements for the class. CEUs are nationally recognized units of achievement that may be used as evidence of professional development and for job advancement. One CEU is awarded for every 10 hours of instruction, totaling 3.6 for this school. A fee of \$10 must accompany the registration fee to receive the CEU credits.

Promotional Video

Need help convincing your organization about the benefits of attending the Hands-On Relay School? Contact us today to request your copy of our promotional video that demonstrates the invaluable training experience of attending this school or view the video at **www.youtube.com/watch?v=Tu5GmeJg7r0**.

Call **800-942-4978** or **509-335-3530** or email us at **wsuconf@wsu.edu** for more information.



HANDS-ON Relay School

MARCH 14-18, 2016

#2086

BY MAIL:

Washington State University
Conference Management
PO Box 645222
Pullman, WA 99164-5222

BY FAX: 509-335-7781**ONLINE:** cm.wsu.edu/hrs

Please print or type. For additional applicants, please duplicate this form. To significantly increase your chances of being accepted, send a facilitator.

Name: _____**Organization:** _____**Title:** _____**Address:** _____**City:** _____**State/Province:** _____**Zip/Postal Code:** _____**Country:** _____**Phone:** _____**Fax:** _____**Attendee email (required):** _____**TRACK SELECTION**

NUMBER only the tracks you will accept in order of preference (1 being your first choice). A letter of confirmed registration and track assignment will be emailed on February 5, 2016. Students will not be allowed to switch tracks once the school has begun.

Manual Relay Testing

- ☐ Basic
- ☐ Distribution M/P
- ☐ Transmission
- ☐ Generation
- ☐ Electromechanical
- ☐ Theory

Automated Relay Testing

- ☐ Doble (Beginning)
- ☐ Doble (Advanced)
- ☐ Enoserv (Beginning)
- ☐ Enoserv (Advanced)
- ☐ Megger AVTS
- ☐ Noram SMC
- ☐ Omicron (Beginning)
- ☐ Omicron (Advanced)

SCHOOL FEE

- ☐ \$650 Please register me for the school (Checks payable to Washington State University, payment in U.S. funds drawn on a U.S. bank.)
- ☐ \$10 I would like Continuing Education Units (CEUs).

PAYMENT METHOD

- ☐ Check enclosed
- ☐ VISA or MasterCard no. _____
Exp. Date _____ CVV# _____
- ☐ Bill my company, purchase order no. _____
Bill to email _____





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PO Box 645222
Pullman, WA 99164-5222



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