

# DISTRIBUTION NEUTRAL GROUNDING AND STRAY VOLTAGE

**May 22-23, 2017**  
**EUCI Offices**  
**4601 DTC Blvd.**  
**Denver, CO**



Photo Credit: Keith Malmedal



EUCI is authorized  
by IACET to offer  
1.5 CEUs for the  
course

## OVERVIEW

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Grounding is one of the most misunderstood areas of distribution engineering. Although good grounding is generally helpful, sometimes improving grounds does little – if anything – to improve system performance, and it may actually have a negative effect. With the widespread addition of renewable and conventional distributed generation, it is important for the practicing engineer to understand the effects of grounding these sources will have on the distribution system. The meaning of the term “stray voltage” is also confusing to some, and is costing the industry millions of dollars in litigation. The purpose of this two-day course is to give the distribution engineer an understanding of the common methods of grounding, when they are commonly used and why, how they are designed and installed, as well as to address current concerns with stray voltage.

## LEARNING OUTCOMES

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- Review distribution systems, including voltage levels, substation and feeder design, equipment ratings and protection philosophies
- Review basic concepts, including Earth as a conductor, mathematical models, step and touch potentials and the impact of good grounding on stray voltage
- Describe system grounding choices and grounding criteria
- Assess substation grounding, including reasons for substation grounding, permissible body current limits, step and touch voltages, use of IEEE Std. 80, and substation fence grounding
- Describe grounding standards and practices
- Demonstrate system grounding principals
- Evaluate the effect of grounding on abnormal voltages, overcurrent protection, lightning and overvoltage protection and electromagnetic interference
- Analyze the causes and effects of stray voltage and mitigation techniques
- Analyze the effects of grounding on renewable and conventional generation and power production facilities

## INSTRUCTOR

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### Keith Malmedal, Ph.D, P.E. P.Eng

**Senior Member, IEEE**

Keith Malmedal has over 25 years combined experience in electrical power system design and system study, teaching, and research, and is presently the President of NEI Electric Power Engineering, Arvada, Colorado. He has published over 30 technical papers in subjects ranging from system grounding to distributed generation. He holds masters degrees in both electrical and civil engineering and his Ph.D research at the Colorado School of Mines was on the effects of renewable energy distributed generation on existing distribution systems in the United States. He teaches undergraduate and graduate classes at Metropolitan State University of Denver and the University of Colorado at Denver, and has taught short courses related to power systems, machines, protection, renewable energy, and energy policy issues for various IEEE chapters and conferences.

# COURSE TIMING

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MONDAY, MAY 22, 2017

|                          |   |
|--------------------------|---|
| <b>8:00 – 8:30 am</b>    | <b>Registration and Continental Breakfast</b> |
| <b>8:30 am – 4:30 pm</b> | <b>Course Timing</b>                          |
| <b>12:00 – 1:00 pm</b>   | <b>Group Luncheon</b>                         |

# PROGRAM AGENDA

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## **Distribution System Overview**

- Voltage levels
- Substation design
- Feeder designs
- Equipment ratings
- Protection philosophies

## **Basic Concepts**

- Earth as a conductor
- General requirements
- Mathematical models (Carson's formulas)
- Ground fault voltage and current calculations (symmetrical components review)
- Step and touch potentials
- Impact of good grounding on safety

## **System Grounding Classifications**

- Definition
- Characteristics
- Ungrounded systems
- Low resistance grounded systems
- High resistive grounded systems
- Solidly grounded systems
- Effectively grounded systems
- Multi-grounded systems and stray voltage

## **Substation Grounding**

- Reasons for substation grounding
- Permissible body current limits
- Step and touch voltages
- Ground grid design using IEEE Std. 80
- Substation fence grounding

## **Distributed Generation Grounding**

- Conventional generator grounding (synchronous generator)
- Renewable power plant grounding (solar, wind, fuel cell, microturbine)
- Use of grounding transformers in power plant grounding
- Grounding effect on harmonic current flow

## COURSE TIMING

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TUESDAY, MAY 23, 2017

**7:30 – 8:00 am**            **Continental Breakfast**

**8:00 am – 4:00 pm**        **Course Timing**

**12:00 – 1:00 pm**         **Group Luncheon**

## PROGRAM AGENDA

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### **Grounding Standards and Practices**

- Neutral grounding rules
- Substation grounding rules and calculations
- Ground electrode rules and calculations
- Pole grounds
- Concrete foundations as pole grounds
- Customer grounds as required by the National Electrical Code
- Underground grounds
- Metallic pipe grounds
- Arrester grounds

### **Ground Resistance Testing**

- Soil resistivity testing
- Four-point resistivity measurements (Wenner and Schlumberger-Palmer Methods)
- Grounding electrodes
- Ground resistance values
- Ground electrode resistance testing methods (fall of potential and clamp-on methods)
- Stray voltage measurements
- Touch potential

### **Effect of Grounding on Swells**

- System temporary overvoltages
- Effect of neutral wire size
- Swell levels
- Division of current
- Effect of number of grounds
- Effect of fault resistance
- Effect of broken neutral
- Effect of ground mat

# PROGRAM AGENDA

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TUESDAY, MAY 23, 2017 (CONTINUED)

**Effect of Grounding on Overcurrent Protection**

- Impact of neutral conductor
- Fault impedance
- Effect of the multi-grounded system
- Special protection problems with distributed generation
- Effect on fault current levels

**Effect of Grounding on Lightning and Overvoltage Protection**

- TOV
- System overvoltages
- Capacitor switching
- Ferroresonance
- Line protection

**Stray Voltage**

- Causes
- Effects on humans and animals
- Mitigation techniques
- Definition and cause of stray voltages

**Impact of Grounding on Electromagnetic Fields**

- Cause of magnetic fields
- Effect of ground current flow

**Special Considerations**

- European systems
- Grounding sensitive equipment
- Maintenance grounding



**REGISTRATION**  
*to register [CLICK HERE](#) or*

**Call: 201 871 0474**  
**fax: 253 663 7224**  
**email: [register@pmaconference.com](mailto:register@pmaconference.com)**  
**web: <http://pmaconference.com/>**  
**Mail: POB 2303 Falls Church Va 22042**

## REQUIREMENTS FOR SUCCESSFUL COMPLETION OF PROGRAM

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Participants must sign in/out each day and be in attendance for the entirety of the course to be eligible for continuing education credit.

## INSTRUCTIONAL METHODS

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PowerPoint presentations, case studies, and workshop exercises will be used in this program.

## PROCEEDINGS

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The proceedings of the course will be published, and one copy will be distributed to each registrant at the course.

## EVENT LOCATION

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### **EUCI Offices**

4601 DTC Blvd.  
Denver, CO 80237

## NEARBY HOTELS

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### **Hyatt Regency Denver Tech Center**

7800 E. Tufts Ave  
Denver, CO 80237  
Phone: 303-779-1234  
0.3 miles away

### **Hilton Garden Inn Denver Tech Center**

7675 E. Union Ave  
Denver, CO 80237  
Phone: 303-770-4200  
0.6 miles away

### **Denver Marriott Tech Center**

4900 S. Syracuse St  
Denver, CO 80237  
Phone: 303-779-1100  
0.7 miles away

### **Hyatt Place Denver Tech Center**

8300 E. Crescent Parkway  
Greenwood Village, CO 80111  
Phone: 303-804-0700  
0.9 miles away

## IACET CREDITS

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EUCI has been accredited as an Authorized Provider by the International Association for Continuing Education and Training (IACET). In obtaining this accreditation, EUCI has demonstrated that it complies with the ANSI/IACET Standard which is recognized internationally as a standard of good practice. As a result of their Authorized Provider status, EUCI is authorized to offer IACET CEUs for its programs that qualify under the ANSI/IACET Standard.

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## EVENT LOCATION

### EUCI Offices

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View nearby hotels on page 6.

## PLEASE REGISTER

- DISTRIBUTION NEUTRAL GROUNDING AND STRAY VOLTAGE COURSE:**  
MAY 22-23, 2017: US \$1495,  
Early bird on or before May 5, 2017: US \$1295

How did you hear about this event? (direct e-mail, colleague, speaker(s), etc.)

Print Name Job Title

Company

What name do you prefer on your name badge?

Address

City State/Province Zip/Postal Code Country

Phone Email

List any dietary or accessibility needs here

### CREDIT CARD INFORMATION

Name on Card Account Number

Billing Address Billing City Billing State

Billing Zip Code/Postal Code Exp. Date Security Code (last 3 digits on the back of Visa and MC or 4 digits on front of AmEx)

**OR** Enclosed is a check for \$ \_\_\_\_\_ to cover \_\_\_\_\_ registrations.

### Substitutions & Cancellations

Your registration may be transferred to a member of your organization up to 24 hours in advance of the event. Cancellations must be received on or before April 21, 2017 in order to be refunded and will be subject to a US \$195.00 processing fee per registrant. No refunds will be made after this date. Cancellations received after this date will create a credit of the tuition (less processing fee) good toward any other EUCI event. This credit will be good for six months from the cancellation date. In the event of non-attendance, all registration fees will be forfeited. In case of course cancellation, EUCI's liability is limited to refund of the event registration fee only. For more information regarding administrative policies, such as complaints and refunds, please contact our offices at (201) 871-0474.