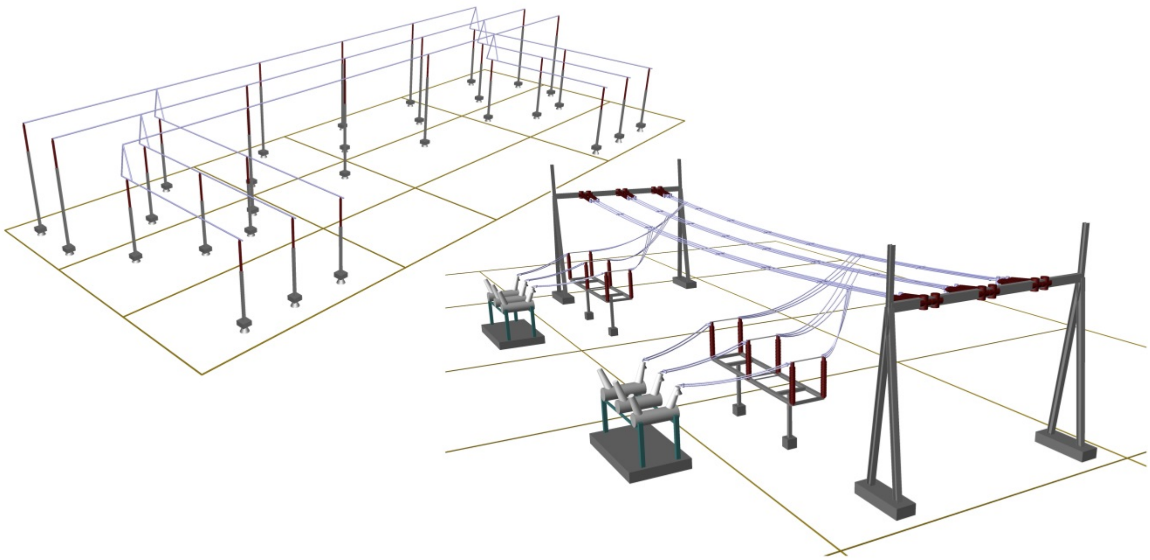
Dynamic Structural Rigid and Flexible Bus Design in Air Insulated Substations

Course Date: June 13-14, 2017



Course Objectives

Understand structural design principles; enable substation bus design and structural analysis of practical substations, consisting of rigid bus as well as strain bus arrangements.

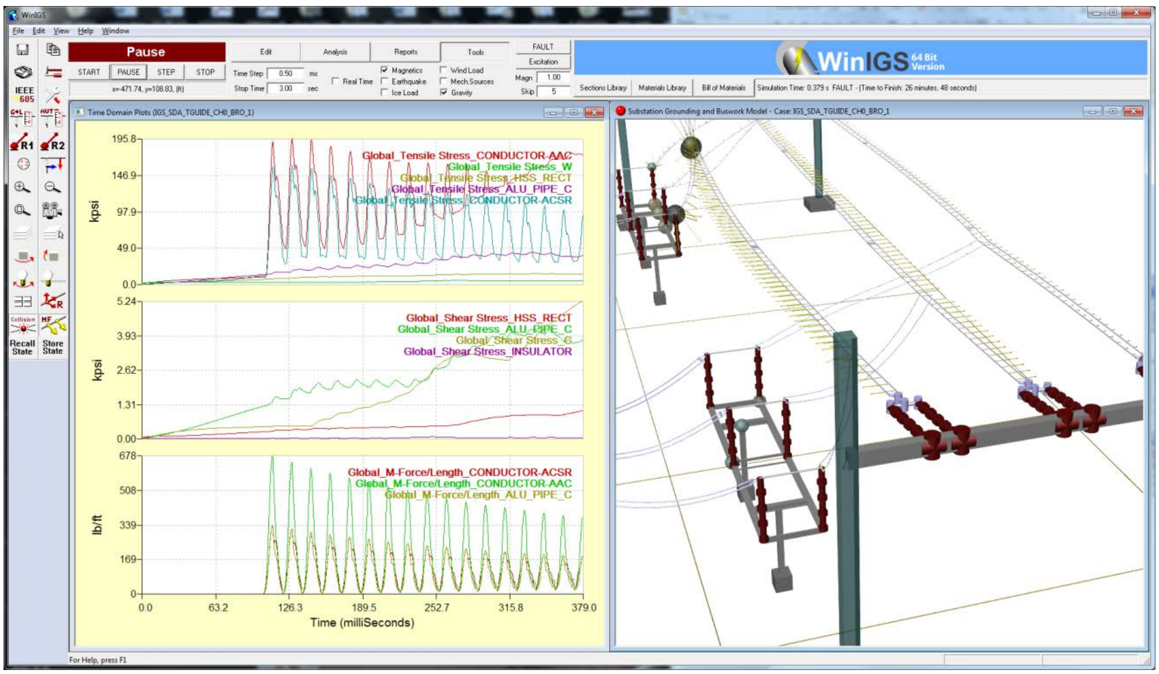
Scope

Increased fault currents result in higher forces on bus structures during fault events. Severe weather effects add to the mechanical loading of bus structures. The high probability of faults during severe weather necessitates design procedures that will result in substation designs that will withstand the combined forces of severe weather and fault current forces and ensure the reliability of the system during these events. Proper structural design of the substation bus structures ensures a safe and reliable operation of the substation and the power system.

This two-day intensive course provides a review of the IEEE Std-605 and other related standards such as the IEC 60865. Basic and advanced analysis methods for both rigid and strain bus design are presented. Static and dynamic modeling and analysis approaches are also presented and compared. The course covers the fundamental principles, as well as the practical methods for the computation of forces and stresses in bus structures, insulators and supports. Guidelines for the selection and verification methods of proper bus/conductor ratings, supporting structures and insulators are discussed. Forces under consideration include magnetic forces (due to fault currents), forces due to wind, and gravitational forces due to weight and ice accumulation. Modeling and analysis requirements needed for the application of standard methods such as ASD and LRFD will be presented.

Throughout the course, the design procedures will be demonstrated with numerous examples of substation bus design using the program WinIGS-SDA which simulates and visualizes bus structure displacements, forces, and stresses. Participants will be provided with a two-month license of the software with which they can perform exercises for their own experience with bus design procedures. The provided software includes prepared examples of substations with rigid bus design, strain bus design and hybrid design for further study.

The course is taught by two experts in the field that developed the program WinIGS-SDA.



Who Should Attend

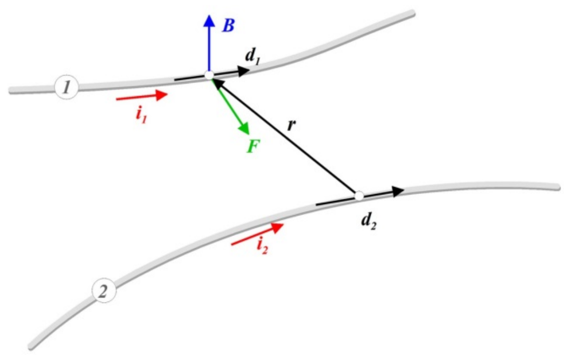
This course is designed for electric power utility engineers and civil engineers involved in the design of substations and electrical installations. It is also intended for consulting and manufacturing engineers and engineers with substation equipment supply companies. University power system educators and graduate students will also benefit from exposure to this important topic. **Prerequisites**: Participants should have an engineering degree (electrical or civil), or equivalent experience.

Course Topics

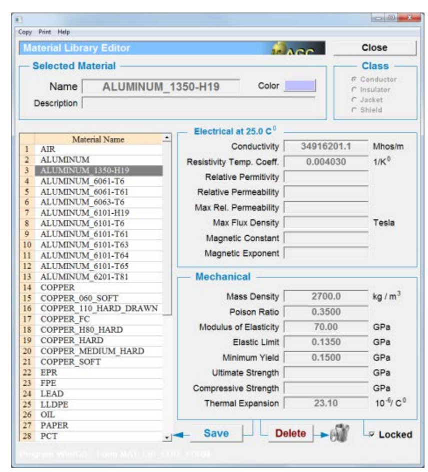
Substation Bus Design standards
- IEEE Standard 605
- IEC 60865
- IEEE Standard 693
- IEEE Standard 1527
- ASTM B188
- ASTM B241/B241M

Substation Bus Arrangements And Design Considerations
- Bus/Breaker Configurations
- Rigid, Strain and Hybrid Bus Structures
- Factors Affecting Bus Design
- Clearances, Insulation, Ampacity
- Bus Design Procedures

Structural Loading Considerations
- Fault currents: Biot Savart forces
- Gravitational forces (weight, ice)
- Forces due to Wind
- Effects of Fault Current Distribution
- Effects of displacement, transients
- Pinch Factor
- Forces on typical bus arrangements
- Typical Examples, Visualization

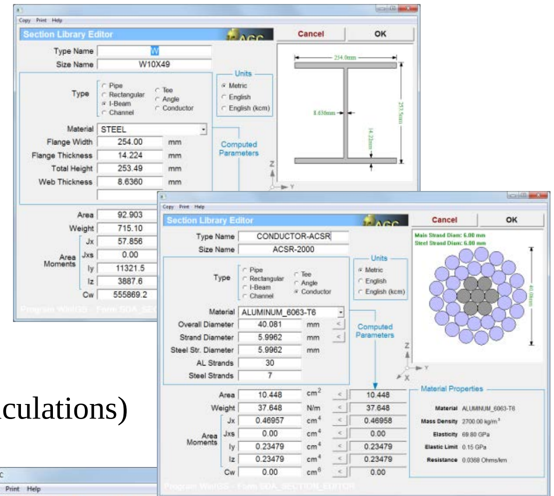


Stress Analysis
- Static vs Dynamic Analysis
- Compression, Tensile & Shear Forces
- Shear and Tensile Stress
- Calculations for Simple Bus Geometries
- Strength of materials under Combined Loading
- LRFD vs ASD
- Rigid Bus Analysis Examples
- Strain Bus Analysis Examples
- Insulators and supports
- Natural Frequencies and Vibration
- Vibration Damping
- Visualization of Typical Examples



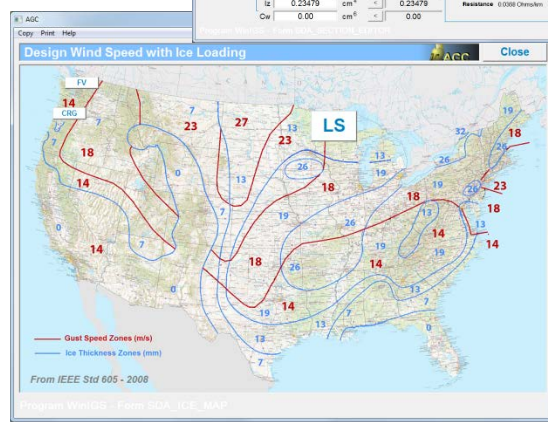
Properties of Materials
- Mechanical Properties
- (Density, Modulus of Elasticity & the Poison Ratio)
- Permissible stresses
- (Elastic Limit, Minimum Yield, Ultimate Strength)

Thermal Properties
(Thermal Expansion, Effect of temperature on strength and deflection)
Electrical Properties
Materials Data Libraries

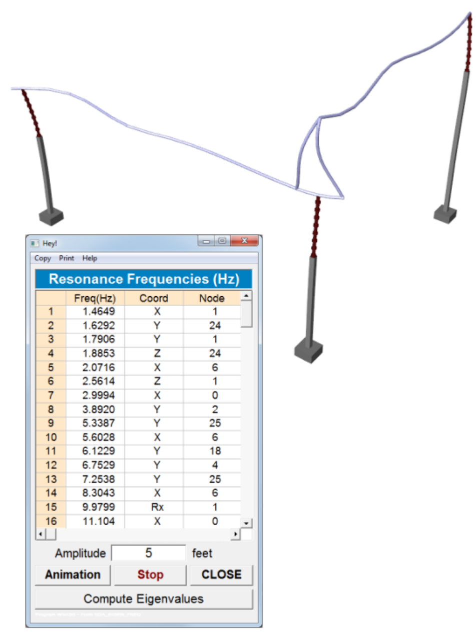


Properties of Sections
- Section Geometry
- Moments of Inertia
- Support Beams, Insulators and Conductors
- Rigid & Strain bus conductors
- Sources of data
- The Sections Library

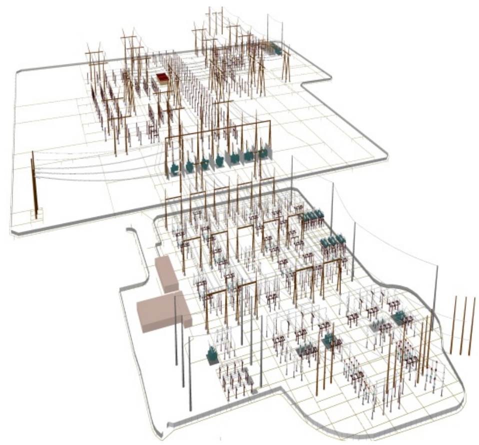
Simple Rigid Bus Analysis Examples (IEEE 605 Hand Calculations)
- Design Specification
- Ampacity
- Corona
- Effects of Mechanical Loads
  - Gravity
  - Ice & Wind
  - Magnetic Forces
  - Thermal Loads
- Other Considerations
  - Maximum Deflection Criteria
  - Insulator Strength
  - Natural Frequencies, Vibration & Damping
  - Clearances



Simple Strain Bus Analysis Examples (IEEE 605 Hand Calculations)
- Design Specification
- Ampacity
- Corona
- Effects of Mechanical Loads
  - Gravity
  - Ice & Wind
  - Magnetic Forces
- Other Considerations
  - Insulator Strength
  - Natural Frequencies, Vibration & Damping
  - Clearances
  - Pinch Factor



Computer Based Bus Structural Dynamic Analysis
- Overview of Numerical Computational Methods
- The finite element and corotational methods
- Data & Modeling Requirements
- Creating the Geometric Model
- Selection of Material and Section Properties
- Applying Connections to Electric Network Model
- Selecting Algorithm Control Parameters
- Reports & Interpretation of Results
- Practical Rigid Bus Analysis Example
- Practical Strain Bus Analysis Example
- Visualization of Forces and Stresses



Course Materials

The following material will be used during the short course presentations:

Extensive class notes.

A. P. Meliopoulos, *WinIGS Structural Dynamic Analysis, Training Guide,* September 2016.

A. P. Meliopoulos, WinIGS-SDA Manual, September 2016.

A copy of the class notes and the training guide will be given to all participants. The WinIGS-SDA manual will be provided in electronic form within the WinIGS-SDA program.

Continuing Education Units

Participants who successfully complete this program will earn 1.6 Continuing Education Units (CEUs). An official transcript of CEUs earned will be provided within 45 days of the completion of the course.

Instructors

A. P. (Sakis) Meliopoulos, Professor of Electrical & Computer Engineering at Georgia Tech, is the course administrator. He joined the Georgia Tech faculty in 1976. His special expertise is in the areas of fault analysis and simulation of power systems, advanced instrumentation for monitoring and protection of power systems, electromagnetic transients, multi-physics modeling and stress analysis, stress analysis, harmonics, grounding and surge protection. He is the leader in the development of the Harmonic Measurement System, which is based on synchronized measurements, the principal inventor of the Smart Ground Multimeter, the WinIGS program and its extensions, the Fault Distance Indicator and the Open Conductor Detector. These software and hardware products are presently used by the industry. He is the author of the books *Power System Grounding and Transients*, Marcel Dekker, Inc, 1988, *Application of Time-Synchronized Measurements in Power System Transmission Networks*, Springer, 2014, Section 27, *Lightning and Overvoltage Protection*, of the Standard Handbook for Electrical Engineers, McGraw Hill, 1993, holds three patents and published over 350 technical papers. Dr. Meliopoulos is the Chairman of the Georgia Tech Protective Relaying Conference and a Fellow of the IEEE.

George Cokkinides obtained the BS, MS, and Ph.D. degrees at the Georgia Institute of Technology in 1978, 1980, and 1985, respectively. He joined the faculty of Electrical and Computer Engineering at the University of South Carolina in 1985 where he is presently an associate professor. His research interests are focused in power system grounding and protection, multi-physics modeling and stress analysis, power electronics applications, power system harmonics, and measurement instrumentation. He has published numerous technical papers, holds one patent, and he has made significant contributions to the EPRI grounding programs, the WinIGS and the smart ground multimeter. Dr. Cokkinides is a member of the IEEE/PES and Sigma Xi.

Course Fee and Registration

The course is offered at $1,400.00 prior to May 19th. After May 19th, the course fee is $1,500.00. Training and course materials are included in the course fee.

Three Ways To Register

☎ **CALL** (512) 636-1448 between 8:00AM – 5PM, Eastern Time.

MAIL registration request and payments to:
Advanced Grounding Concepts
P. O. Box 49116
Atlanta, Georgia 30359

EMAIL your registration to deeanne@ap-concepts.com

Please be prepared to provide your name, address, company/affiliation, email and phone contact information and your desired method of payment.

Payment

Payment Options: (1) check, (2) direct deposit. In case of **direct deposit**, you will receive information for a direct transfer upon registration. Make **checks payable** to Advanced Grounding Concepts.

You will receive an email confirming your registration.

To optimize training results, the course will be limited to 30 participants. As a result, you are encouraged to register early. Payment must be received **by May 19, 2017** to ensure your place and "Early Bird" fee of **$1400.00** inclusive of instruction and materials. **After May 19, 2017**, registrations will be accepted if seats are still available at **$1500.00.**

Registration Questions?

DeeAnne Abernathy
AGC Event Coordinator
Email: deeanne@ap-concepts.com
Phone: (512) 636-1448

Course Dates

June 13-14, 2017
8:00AM – 4:30 PM daily

Location and Accommodations

The course will be held at the Emory Conference Center Hotel in Atlanta Georgia. A block of rooms has been reserved at a special rate. **Attendees will be responsible for reserving hotel rooms.**

Emory Conference Center Hotel,1615 Clifton Road NE
Atlanta, GA 30329

Reservations can be made online or by calling:
Link: https://aws.passkey.com/go/AdvancedGroundingConcepts.
In House Reservations: 1-800-933-6679. After Hours: 1-877-237-6177.

Continental breakfast, lunch and mid-morning and afternoon snacks will be provided both days. Please advise if there are any special dietary considerations.

The hotel is nestled next to a 26-acre nature preserve. Shopping and dining options are located steps away from the hotel. A complimentary hotel shuttle is also available within a one-mile radius from the hotel. To learn more about the Emory Conference Center Hotel, go to this link: http://www.emoryconferencecenter.com.

Transportation

A map and directions to The Emory Conference Center Hotel can be found at this link http://www.emoryconferencecenter.com/map-and-directions.htm.

Public transportation from the airport is available through MARTA (Metropolitan Atlanta Rapid Transit Authority). The Airport MARTA station is conveniently located next to Delta Baggage Claim. A MARTA fare is $2.50 for a one-way trip. From the Airport, there are two trains that head Northbound. You can proceed to the Lindbergh MARTA Station on either train. The conference center is approximately 3.7 miles from the Lindbergh MARTA station. Taxis, buses and Uber are available at the Lindbergh MARTA station as outlined in the link above.

Here is a link to a map of the MARTA stations if you would like to learn more about it: http://www.itsmarta.com/train-stations-and-schedules.aspx

Traditional transportation is available from the airport. Uber and Lyft **may** be available at the Atlanta Airport by the June timeframe. With rideshare, a $3.85 surcharge per ride is currently being proposed.

The Emory Conference Center Hotel offers an onsite Enterprise rental car facility.

Course Substitutions, Cancellations, and Refund Policy

Substitutions

Substitutions can be made prior to the beginning of the course. Please contact DeeAnne Abernathy, AGC Event Coordinator, to make the substitution and to provide contact information for the substitute.

Cancellations

All cancellation requests by the attendee must be received more than 10 business days prior to the event start date to be eligible for a refund less a $100 processing fee. Substitutions may be made prior to the beginning of the seminar. “No shows” are not eligible for a refund. If the course is cancelled due to low enrollment or for some other administrative reason, you will receive an e-mail notification and a full refund.