

Welcome Message

Welcome to the fifth biennial Electric Ship Technology Symposium. For nearly a decade, the ESTS has served as a venue for communicating the latest advances in electric ship technologies amongst academia, industry, and navy partners. We do this through a combination of formal presentations, panel sessions, and informal interactions, all of which contribute to the success of this meeting. As with all meetings, it is what you make it to be, and so we invite your fullest participation and engagement in our technical exchanges.

This year, the IEEE Power and Energy Society has assumed primary sponsorship of the symposium, and PES is joined by the IEEE Power Electronics Society and the IEEE Industry Applications Society as co-sponsors.

Financial support for the symposium has also been provided by the U.S. Office of Naval Research and by Silver Patrons RTDS and ABB. We heartily thank them for their support. Although federal budget issues have presented significant challenges this year, in the end we have assembled a strong and diverse technical program and a long list of participants. We are pleased that you are able to join us, and we hope that you will contribute in meaningful ways to our technical exchange. As the following pages reveal, the symposium will convey new progress and technical understandings in many areas that are critical to realizing electric ships: How can we best integrate complementary technologies such as energy storage and pulsed loads? How can ship systems capitalize on the newest methods for simulation-based

analysis and electronic design? Which higher-performance, higher-energy-density power electronics and machines might permit us to fit all of the essential equipment into a ship? What new power system architectures and operating strategies will allow us to maximally exploit the benefits of electric ships? Join me and a wonderful cast of experts as we discuss, debate, advance, and – someday – resolve these and other challenging issues.

Prof. Roger Dougal
Chair, ESTS 2013
Department of Electrical Engineering
University of South Carolina

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Keynote Speaker

Dr. Norbert Doerry

**Technical Director, SEA 05 Technology Group
SEA 05TD**

Dr. Norbert Doerry is the Technical Director of the NAVSEA SEA 05 Technology Office. He currently is on a detail with the U.S. Marine Corps as the Design Manager of the Amphibious Combat Vehicle. He retired from active duty in the United States Navy in 2009 as a Captain with 26 years of commissioned service, 23 years as an Engineering Duty Officer. In his final billet, he served for nearly six years as the Technical Director for Surface Ship Design. Dr. Doerry is a 1983 graduate of the United States Naval Academy and a 1991 graduate of MIT. He is the 2008 recipient of the ASNE Gold Medal. He is a member of ASNE, IEEE and the Naval Institute; is a SNAME fellow; has published over 35 technical papers and technical reports; and has participated in the development of over seven technical standards.



Keynote Speaker

Rear Admiral Matthew L. Klunder **Chief of Naval Research/Director,** **Innovation, Technology** **Requirements, and Test & Evaluation**

Rear Adm. Klunder, a native of Alexandria, Va., graduated from the United States Naval Academy in 1982 and earned his wings of gold at Meridian, Miss., in September 1984. Subsequent flying tours were based in Naval Air Station (NAS) Miramar, Calif.; NAS Patuxent River, Md.; Naval Air Facility Atsugi, Japan; and NAS Lemoore, Calif., where he was qualified in numerous aircraft including the E-2C Hawkeye and F/A-18 E/F Super Hornet. In November 2011, he became the 24th Chief of Naval Research, with additional duties as director, Test Evaluation and Technology Requirements. Klunder received his bachelor's degree from the U.S. Naval Academy, a master's degree in Aerodynamics and Aviation Systems from the University of Tennessee, and a master's degree in Strategic Studies from the National War College. He has flown more than 45 different aircraft and accumulated 21 world-flying records. His awards include the Legion of Merit (four Awards), Defense Meritorious Service Medal (two Awards), Meritorious Service Medal (two Awards), Joint Commendation Medal (two Awards), Navy and Marine Corps Commendation Medal (four Awards) and various unit and campaign awards.



ESTS 2013 SCHEDULE

Sunday, April 21

6:30 pm

Welcome Reception, *Masters Ballroom*

Monday, April 22

7:00 am

Breakfast

8:00 am

Welcome

8:15 am

Keynote

8:45 am

Panel - Pulsed loads and energy storage

10:30 am

Coffee Break

10:45 am

Pulsed Loads

Analysis I

12:30 pm

Lunch

2:00 pm

Modeling &
Simulation I

Propulsion

3:45 pm

Coffee Break

4:00 pm

Design Tools

Power Conversion

Tuesday, April 23

7:00 am

Breakfast

8:00 am

Keynote

8:45 am

Panel Session 2 - Challenges in
transitioning shipboard architecture

10:15 am

Coffee Break

10:30 am

Integrated Power
System

Machines and
Drives

12:15 pm

Lunch

1:45 pm

Modeling &
Simulation II

System
Architecture

3:30 pm

Coffee Break

3:45 pm

Power System
Control

Testing and
Certification

5:30 pm

Break

7:00 pm

Dinner

Wednesday, April 24

7:15 am	Breakfast		
8:15 am	Power Conversion II	Reconfiguration and Survivability	Analysis II
10:00 am	Coffee Break		
10:15 am	Electrical Components	Fault Protection	
12:00 pm	End Symposium		

Room Locations

All breakfasts, lunches and dinner will be in the *Masters Ballroom*

All technical sessions will be in the *Gallery Ballrooms*

ESTS 2013 PROGRAM

Sunday, April 21

6:30pm–8:00pm....Welcome Reception
Masters Ballroom

Monday, April 22

7:00 amBreakfast

8:00 amOpening Remarks -Roger Dougal
Gallery Ballroom

8:15 amKeynote Address - Norbert Doerry
Gallery Ballroom

8:45 amA1L-P
**Panel Session 1 - Integration of Pulsed
Loads and Energy Storage into Shipboard
Power Systems**

Ed Wagner, RCT Systems

Don Hoffman, ONR Energy Storage systems

Charles Garnett, ONR EM Rail Gun

*Vince Kane, TWH Total Ship Power/Integrated
Power Sys NAVSEA*

*Mark McGranaghan, VP Power Delivery and
Utilization – EPRI*



10:30 am ...Coffee Break

10:45 am ...A1L-A

Integration of Pulsed Loads

Chair: Herb Ginn, University of South Carolina

Design of a Battery Intermediate Storage System for Rep-Rated Pulsed Power Loads

Brett M. Huhman, Jesse M. Neri, David A. Wetz

The Impact of Power Quality when High Power Pulsed DC and Continuous AC Loads are Simultaneously Operated on a MicroGrid Testbed

Jay P. Kelley, David A. Wetz, James A. Reed, Isaac J. Cohen, Gregory K. Turner, Wei-Jen Lee

Rotating Machine Technologies for Integration of Pulsed and High Power Loads in Naval Electric Power Systems

John Herbst, Abdelhamid Ouroua, Angelo Gattozzi, Siddharth Pratap

Monitoring Pulsed Power on Ship Electrical Systems

George L Kusic, John M. Heinzl, Donald J. Hoffman

Specifications and Standards for the Electric Warship

Norbert Doerry, Khosrow Moniri

10:45 am ...A1L-B

Analysis I

Chair: Mischa Steurer, Florida State University

DQ Impedance of a Regulated Synchronous Machine

Mohamed Belkhat, Jesus Ivan Gonzalez, Jacob Verhulst

Electrical Machine Iron Loss Predictions – A Unique Engineering Approach Utilizing Transient Finite Element Methods – Part 1: Theory and Calculation Method

Joshua Lorenz

Time and Frequency Domain Methods to Evaluate Grounding Strategies for Medium Voltage DC Shipboard Power Systems

L. Graber, M. Steurer, J. Kvitkovic, M. Kofler, S. Pekarek, R.A. Howard, A. Taher, M.S. Mazzola, A.E. Card

Determination of Remaining Life of Rotating Machines in Shipboard Power Systems by Modeling of Dielectric Breakdown Mechanisms

Yaw D. Nyanteh, Lukas Graber, Sanjeev Srivastava, Chris Edrington, David Cartes, Horatio Rodrigo

Thermal Management Aspects of All-Electric Ships

Juan C. Ordonez, Alejandro Rivera, Sam Yang, Darshit Shah, David Delgado, Michael Coleman, Emerson Dilay, Jose V.C. Vargas

12:30 pm ...Lunch

2:00 pmA2L-A

Modeling & Simulation I

Chair: Scott Sudhoff, Purdue University

Co-Simulation of a Marine Electrical Power System using PowerFactory and MATLAB/Simulink

Xin Kong, Xiaoxiao Yu, Ricky R. Chan, Meng Yeong Lee

Discrete-Time Modeling of Multiple-Input DC Energy Conversion Systems

Hamid Behjati, Ali Davoudi

FPGA Model of a High-Frequency Power Electronic Converter in an RTDS Power System Co-Simulation

R. Meka, M. Sloderbeck, O. Faruque, J. Langston, M. Steurer, L.S. DeBrunner

Developing a Validated Real-Time System-Level Thermal Simulation for Future All-Electric Ships

Tim Chiochio, Raimund Schrattenecker, Sam Yang, Juan Ordonez, Mischa Steurer

Assessing Confidence in Parallel Simulation Results

Fabian M. Uriarte, Robert E. Hebner

2:00 pmA2L-B

Propulsion

Chair: Volker Staudt, Ruhr-Universität Bochum

System Studies for a Bi-Directional Advanced Hybrid Drive System (AHDS) for Application on the DDG-51 Platform

James Langston, Michael Andrus, Michael Steurer, Dwight Alexander, Jeff Buck, George Robinson, Don Wieczenski, Adam Goldberg

Double Fed Induction Machine for Electrical Naval Propulsion

Mustapha Debbou, Maria Pietrzak-David

Electric Ship Propulsion Drive Motors – A Review

J.S. Thongam, M. Tarbouchi, A.F. Okou, D. Bouchard, R. Beguenane

Defining and Achieving Rated Shaft Power in Electric Propulsion Systems at Sea Trials for New U.S. Navy Ships

Thomas C. Dalton

Dynamic Modeling and Stability Analysis of an Experimental Test Bench for Electric-Ship Propulsion

Reza Ahmadi, Hamid Behjati, Mehdi Ferdowsi

3:45 pmCoffee Break

4:00 pmA3L-A

Design Tools

Chair: Giorgio Sulligoi, Università degli Studi di Trieste

Marine Electrical Plant Model Code Optimization to Achieve Soft Real-Time Execution

Martin Malenshek, Matthew Boley, Michael Burke

**Modular IPS Machinery Arrangement in
Early-Stage Naval Ship Design**

*David J. Jurkiewicz, Julie Chalfant,
Chrys Chryssostomidis*

**Shipboard Electrical System Modeling for
Early-Stage Design Space Exploration**

Aaron M. Cramer, Hanling Chen, Edwin L. Zivi

**A General Algorithm to Automatically Create
Admittance Matrices for Electric Networks**

*Arash Asrari, Mohamed Alattar, Sherif Abdelwahed,
Michael Mazzola*

**Multicore Methods to Accelerate Ship Power
System Simulations**

Fabian M. Uriarte, Christian Dufour

4:00 pmA3L-B

Power Conversion I

Chair: Enrico Santi, University of South Carolina

**Sculpting the Dynamic Response of PWM
DC-DC Converters in an Arbitrary Shape
using WPI Control Technique**

Hamid Behjati, Ali Davoudi, Reza Ahmadi

**Average-Value Modeling of a Peak-Current
Controlled Galvanically-Isolated DC-DC
Converter for Shipboard Power Distribution**

H. Suryanarayana, S.D. Sudhoff

**Three-Level Inverter with 60 A, 4.5 kV Si
IGBT/SiC JBS Power Modules for Marine
Applications**

Kathleen Lentijo, Karl Hobart

**Fault-Aware-Soft-Restart Method for
Shipboard MVAC Power System using
Inverter Coupled Energy Storage System**

*Asif Anwar, Huaxi Zheng, Roger A. Dougal,
Yucheng Zhang*

**State Control of MMC-Fed Ship Propulsion
Induction Machine**

M. Spichartz, C. Heising, V. Staudt, A. Steimel

Tuesday, April 23

7:00 amBreakfast

8:00 amKeynote Address - Admiral Klunder
Gallery Ballroom

8:45 amB1L-P

**Panel Session 2 - Challenges in
transitioning shipboard architecture**

*Cdr Gennaro Lipardi, Directorate for Naval
Armaments, Italian Navy*

Khosrow Moniri, TWH - electrical systems NAVSEA

Tim McCoy, Director PMS320

Joe Borraccini , ONR Shipboard electrical Power

*Jan-Fredrik Hansen, Technology Manager, COE
O&G Vessels, ABB*

10:15 am ...Coffee Break

10:30 am ...B1L-A

Integrated Power System

*Chair: Zareh Soghomonian, QinetiQ North
America, Inc*

**A Novel Control Principle for All-Electric
Ship Power Systems**

*Mehdi Farasat, Amir Saman Arabali,
Andrzej M. Trzynadlowski*

**Integrated Simulation Framework for
Crash Back Operation**

*Pradya Prempraneerach, Stefano Brizzolara, George
E. Karniadakis, Chryssostomos Chryssostomidis*

**Shipboard IPS Technological Challenges-
VFD and Grounding**

*Mohammed (Moni) Islam, William Hinton,
Michael McClelland, Kevin Logan*

**Improving Gas Turbine Generator Capability
using a Load Compressor**

Jason K. Ostanek, Carl Grala

Comparing Point of use Power Quality to System Level Power Quality in a Shipboard MVDC Distribution System

John P. Stubban, Brian K. Johnson, Herb Hess

10:30 am ...B1L-B

Machines and Drives

Chair: Giorgio Sulligoi, Università degli Studi di Trieste

Brushless Wound-Rotor [Synchronous] Doubly-Fed Electric Machine Stabilized by Real-Time Control

Frederick William Klatt

Multi-Megawatt Drive with Intercell Transformers

Shrutish Dawande, Kathleen Lentijo

A Closer Look to Conventional Hydraulic Ship Actuator Systems and the Convenience of Shifting to (Possibly) All-Electric Drives

C. Bruzzese, A. Tessarolo, T. Mazzuca, G. Scala

An Analytical Design Model for Wound Rotor Synchronous Machines

Omar Laldin, Scott D. Sudhoff, Steven D. Pekarek

Modular Multilevel Converter for Propulsion System of Electric Ships

M. Spichartz, V. Staudt, A. Steimel

12:15 pm ...Lunch

1:45 pmB2L-A

Modeling & Simulation II

Chair: Jim Kirtley, Massachusetts Institute of Technology

Simulation of Large-Scale Electric-Ship AC Grids using the Simulation Tool VIAvento

R. Bartelt, D. Meyer, C. Heising, V. Staudt

Modeling and Simulation of Shipboard Nonlinear Dynamic Loads using Volterra Kernels

Jesse Leonard, Chris S. Edrington

Reduced Order Modeling of a Shipboard Power System

S. Abdelwahed, A. Asrari, J. Crider, R.A. Dougal, M.O. Faruque, Y. Fu, J. Langston, Y. Lee, H.A. Mohammadpour

Using FPGAs for Low-Cost High-Performance Simulations

John Zenor, Richard Bednar, Roy Crosbie, Dale Word, Kurtis Kredo II, Narain Hingorani

Simulation of Large-Scale Electric-Ship DC-Grids using the Simulation Tool VIAvento

R. Bartelt, D. Meyer, C. Heising, Y. Khimchenko, V. Staudt

1:45 pmB2L-B

System Architecture

Chair: Fabian Uriarte, University of Texas at Austin

Electric Generation Technologies for All-Electric Ships with Medium-Voltage DC Power Distribution Systems

A. Tessarolo, S. Castellan, R. Menis, G. Sulligoi

Distributed Control for AC Shipboard Power Systems

Ali Bidram, Ali Davoudi, Frank L. Lewis

Application of Disturbance Metrics for Reducing Impacts of Energy Storage Charging in an MVDC based IPS

Yusheng Luo, Sanjeev Srivastava, Mike Andrus, David Cartes

Transient Stability of High Frequency AC Power Systems

Huaxi Zheng, Roger A. Dougal, Mohd. Hasan Ali

Pinisi: Low-Cost Unmanned Surface Vehicle (USV) Assisted by Android Smartphone

Adi Wiguna, Galih Gilang, Ridho Wastu, Widyawardana Adiprawita



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3:30 pmCoffee Break

3:45 amB3L-A

Power System Control

Chair: David Cartes, Florida State University

**MVDC Power System Voltage Control
through Feedback Linearization Technique:
Application to Different Shipboard Power
Conversion Architectures**

A. Vicenzutti, D. Bosich, G. Sulligoi

**Decentralized Linear Quadratic Gaussian
Control of Multi-Generator MVDC
Shipboard Power System with Constant
Power Loads**

Lin Zhu, Junqi Liu, Marco Cupelli, Antonello Monti

**Considerations on the Design of Voltage
Control for Multi-Machine MVDC Power
Systems on Large Ships**

*Giorgio Sulligoi, Daniele Bosich,
Vittorio Arcidiacono, Giovanni Giadrossi*

**Effects of Communication Network and Load
Parameters on Information-Embedded Multi-
Converter Shipboard Power Systems**

*Juan C. Jimenez, Sachi Jayasuriya, Chika
O. Nwankpa*

**Accounting for System-Level Controls during
Early-Stage Design**

Tianlei Zhang, Roger A. Dougal, Yucheng Zhang

3:45 amB3L-A

Testing and Certification

*Chair: Mohamed Belkhayat, Huntington Ingalls
Newport News*

**Electromagnetic Compatibility in Ships
Design and Construction**

Víctor Hugo Jiménez González

**Role of Hardware-in-the-Loop Simulation
Testing in Transitioning New Technology to
the Ship**

*James Langston, Michael Sloderbeck, Michael Steurer,
Donald Dalessandro, Tom Fikse*

**Limiting Hull Touch Voltages in Large Power
Shore Connection Systems during Phase-to-
Ground Faults: A Solution Proposal**

*Giorgio Sulligoi, Daniele Bosich, Riccardo Baldi,
Fabio Tosato*

**Improved Power Hardware in the Loop
Interface Methods via Impedance Matching**

Sanaz Paran, Chris S. Edrington

**Accelerated Electrical Aging of Medium
Voltage EPR Cables Energized by Elevated
AC Voltage with Switching Impulses
Superimposed**

L. Cao, S. Grzybowski, B. Pradhan

5:30 pmBreak

7:00 pmDinner



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Wednesday, April 24

7:15 amBreakfast

8:15 amC1L-A

Power Conversion II

Chair: Chris Edrington, Florida State University

Variable Speed Operation of Turbogenerators to Improve Part-Load Efficiency

Dan Li, Roger A. Dougal,

Eshwarprasad Thirunavukarasu, A. Ouroua

High Power Density and High Efficiency Converter Topologies for Electric Ships

J.D. Herbst, F.D. Engelkemeir, A.L. Gattozzi

Pole-Restraining Control for Modular Multilevel Converters in Electric-Ship Applications

Carsten Heising, Tim Schrader, Roman Bartelt,

Volker Staudt, Andreas Steimel

Voltage Regulation in Medium Voltage DC Systems

Farhad Barati, Dan Li, Roger A. Dougal

8:15 amC1L-B

Reconfiguration and Survivability

Chair: Julie Chalfant, Massachusetts Institute of Technology

On-Line Monitoring of Mechanical Unbalance/ Misalignment Troubles in Ship Alternators by Direct Measurement of Split-Phase Currents

C. Bruzzese, T. Mazzuca, M. Torre

Reliability Analysis of a Shipboard Electrical Power Distribution System based on Breaker-and-a-Half Topology

B. Stevens, S. Santoso

Smart Electrical Protection Method for Industries Operations

Abdul Hasib Siddique, Braham Barkat, Majid Poshtan

An Effective Filtering Algorithm to Mitigate Transient Decaying DC Offset

Abouzar Rahmati, Reza Adhami

Machine Learning based Diagnosis Support for Shipboard Power Systems Controls

Ranjit Amgai, Jian Shi, Renz Santos, Sherif Abdelwahed

8:15 amC1L-C

Analysis II

Chair: Siddharth Pratap, University of Texas at Austin

Stability Analysis of an All-Electric Ship MVDC Power Distribution System using a Novel Passivity-Based Stability Criterion

Antonino Riccobono, Enrico Santi

Generic Modeling and Analysis Framework for Shipboard System Design

Jian Shi, Ranjit Amgai, Sherif Abdelwahed, Abhishek Dubey, Josh Humphreys, Mohamed Alattar, Rui Jia

Studies of Electromechanical Transients in FREMM Frigates Integrated Power System using a Time-Domain Simulator

G. Sulligoi, D. Bosich, A. Vicenzutti, L. Piva, G. Lipardi, T. Mazzuca

Wide Bandwidth System Identification of MVDC Distribution System by Applying Perturbations to an Existing Converter

Jonathan Siegers, Enrico Santi, Adam Barkley

Evaluation of Gas Turbine Engine Dynamic Interaction with Electrical and Thermal System

Eshwarprasad Thirunavukarasu, Ruixian Fang, Jamil A. Khan, Roger Dougal

10:00 am ...Coffee Break

10:15 am ...C2L-A

Electrical Components

Chair: Michael Mazzola, Mississippi State University

Tools and Dielectric Requirements for the Design of Marine Cabling Systems

M. Mazzola, A. Card, S. Grzybowski, M. Islam, L. Graber, H. Rodrigo

Water Impermeable, Easy-Disconnect Electrical Cable Connector for Deep Sea Applications

Marcel Gaudreau, Michael Kempkes, Nicholas Reinhardt, Ken Schrock, Kevin Vaughan

A Novel Fault-Tolerant High-Thrust Inverter-Controlled Permanent Magnet Linear Actuator as a Direct-Drive for Shipboard Loads

A. Tessarolo, C. Bruzzese, T. Mazzuca, G. Scala

Mechanical Power-Hardware-in-the-Loop: Emulation of an Aeroderivative Twin-Shaft Turbine Engine

Blanca A. Correa, Yucheng Zhang, Roger A. Dougal, Tim Chiochio, Karl Schoder

Permanent PD Monitoring: The On-Board Solution to Prevent Failures for Propulsion, Distribution and Generation Systems in Marine Applications

L. Fornasari, A. Cavallini, G.C. Montanari

10:15 am ...C2L-B

Fault Protection

Chair: Moni Islam, M&R Global

**Short-Circuit Protection Issues in DC Ship
Grids**

Volker Staudt, Roman Bartelt, Carsten Heising

Optimization of a Z-Source DC Circuit Breaker

*P. Prempraneerach, M.G. Angle, J.L. Kirtley Jr.,
G.E. Karniadakis, C. Chryssostomidis*

Energy based Fuse Modeling and Simulation

Dan Li, Li Qi

**Coordination between Supply Power
Converters and Contactors for Fault
Protection in Multi-Terminal MVDC
Distribution Systems**

Pietro Cairoli, Roger A. Dougal, Kathleen Lentijo

Design of DC System Protection

*Arthur H. Chang, Al-Thaddeus Avestruz,
Steven B. Leeb, James L. Kirtley Jr.*

12:00 pm ...End Symposium

NOTES