INNOVATING NUCLEAR TECHNOLOGY

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

CHAD J. KIGER, PH.D., P.E.

EMC Engineering Manager

As EMC Engineering Manager at AMS, **CHAD J. KIGER** is responsible for overseeing the development of EMC and cable testing capabilities, as well as identifying and procuring the test equipment necessary to perform all facets of EMC and electromagnetic interference (EMI) testing for private clients, utilities, and nuclear power plants throughout the world. An iNARTE–certified EMC Engineer and MIL-STD EMC Specialist, Dr. Kiger has performed EMC qualification testing in nearly 100 nuclear facilities and equipment manufacturers across the U.S. and abroad, including data review and site assessments of the electromagnetic environment. He is also actively engaged in numerous international activities, including projects through the International Atomic Energy Agency (IAEA) and the International Electrotechnical Commission (IEC).

Dr. Kiger has been involved in numerous industry conferences, serving in various capacities from technical session chair to main presenter. He is a Fellow of the International Society of Automation (ISA) and an executive committee member of ISA POWID. In addition, he is a member of the American Nuclear Society (ANS), Institute of Electrical and Electronic Engineers (IEEE), Nuclear Energy Institute (NEI), U.S. National Committee Technical Advisory Group (TAG), and Electric Power Research Institute (EPRI) Nuclear EMC Working Group, which develops guidance for nuclear industry with respect to EMI.

Dr. Kiger has served as the principal investigator for a $2.5M wireless Phase III project to implement numerous wireless systems inside the containment at Arkansas Nuclear One (ANO) Power Plant, and was the lead EMC engineer at Diablo Canyon Power Plant in California to help allow the use of cell phones throughout various areas of the power block. In addition, he has provided recommendations with regard to EMI/RFI to assist with various plant activities including temporary equipment installations during refueling outages.

Prior to joining AMS in 2006, Dr. Kiger performed his graduate work at the University of Tennessee–Knoxville, Wireless Communications Research Group (WCRG) and Oak Ridge National Laboratory (ORNL). From the work on his thesis entitled “Physical Layer Simulation Study for the Co-existence of Wireless Local Area Network (WLAN) Standards,” the NUREG/CR-6939 of the NRC was published through ORNL. He completed a graduate assistantship and a period of employment at ORNL supporting activities in wireless technology research and development (R&D) and applications.

EDUCATION & CERTIFICATIONS

Ph.D., Electrical Engineering and Radio Frequency Communications and Signal Processing, Tennessee Technological University (2019)

MSc, Electrical Engineering, University of Tennessee–Knoxville (2005)

BSc, Electrical Engineering, University of Tennessee–Knoxville (2004)

Professional Engineer, State of Tennessee, License #118572

Certification—iNARTE EMC Engineer (since 2012)

Certification—iNARTE MIL-STD EMC Specialist (since 2012)

Certification—LabVIEW software developer (since 2007)

Certification—Engineer Intern in the State of Tennessee (2003)

Chad J. Kiger, Ph.D., P.E.

Professional Activities

Dr. Kiger has been involved in numerous industry conferences, serving in various capacities from technical session chair to main presenter. He has been involved with the IAEA Coordinated Research Project Meeting "Qualification, Condition Monitoring, and Management of Aging of Low Voltage Cables in Nuclear Power Plant Life Management," held in Knoxville, Tennessee (July 2013), as well as the Second Research Coordinated Meeting (RCM) related to the IAEA CRP on "Improved I&C Maintenance Techniques for Research Reactors," held in Vienna, Austria (February 2014). Most recently, he has served two consecutive years (2016 and 2017) as the Nuclear Program Chair for the Annual ISA Power Industry Division (POWID) Symposium. He has also served as Session Chair and presenter at the American Nuclear Society's 9th (2015) and 10th (2017) International Topical Meeting on Nuclear Plant Instrumentation, Control & Human–Machine Interface Technologies (NPIC & HMIT).

MEMBERSHIPS & AFFILIATIONS

- Fellow, International Society of Automation (ISA)
- Senior Member, Institute of Electrical and Electronic Engineers (IEEE)
- Member, National Society of Professional Engineers (NSPE)
- Member, Tennessee Society of Professional Engineers (TSPE)
- Member, American Nuclear Society (ANS)
- Member, American National Standards Institute (ANSI)
- Past Member, Nuclear Energy Institute (NEI)
- Chief Scientific Investigator (CSI) for IAEA Coordinated Research Project (CRP) on Wireless Technology Implementation in Nuclear Power Plants
- Member, U.S. National Committee Technical Advisory Group (TAG)
- Member, Electric Power Research Institute (EPRI) Nuclear EMC Working Group
- Project Leader for IEC 62003 Standard, "Nuclear Power Plants—Instrumentation and Control Important to Safety—Requirements for Electromagnetic Compatibility Testing"
- Project Co-Leader for IEC 62988 Standard (in development), "Control Systems Important to Safety—Selection and Use of Wireless Devices"
- Working Group Chair for IEEE 473 Standard, "Recommended Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz)"
- Nuclear Program Chair, 59th (June 2016) and 60th (June 2017) POWID Symposium, Cleveland, OH
- Session Chair, 9th (February 2015) and 10th (June 2017) NPIC & HMIT Topical Meeting, Charlotte, NC
- Executive Committee Member, ISA POWID (Inducted in June 2014)
- Session Chair at the 2013 and 2014 ISA POWID Symposium
- Standards and Practice Chair for the Local ISA Section in 2009

Chad J. Kiger, PH.D., P.E.

Awards & Honors

2018	Ted Quinn Early Career Award by the Human Factors, Instrumentation and Controls Division (HFICD) of the American Nuclear Society (ANS)
2016	Elected to the distinguished grade of ISA Fellow
2016	Professional Engineering License, State of Tennessee
2015	Citation by the General Chairman of the American Nuclear Society's Topical Conference on Instrumentation, Control & Human-Machine Interface Technologies
2015	Robert L. Long Training Excellence Award by the American Nuclear Society (ANS)
2014–2015	Awarded "One of the Two Best Technical Papers" from the 2014 ISA POWID Symposium
2013	Second Best Paper Award at the 57th Annual POWID Symposium of ISA
2012	iNARTE EMC Engineer Certification (International Association for Radio, Telecommunications and Electromagnetics)
2012	iNARTE MIL-STD EMC Specialist Certification
2012	American Association for Laboratory Accreditation (A2LA) (approval of EMC Lab developed by Mr. Kiger)
2007	LabVIEW Software Developer Certification

National Conference Presentations

Kiger, C., "In-Situ Electromagnetic and Radio Frequency Interference Testing of Equipment in the Main Control Room of the Krško Nuclear Power Plant." American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Kiger, C., "Distributed Antenna Systems for Wireless Connectivity in Nuclear Power Plants." American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Agarwal, V., Buttles, J., Al-Rashdan, A., Pitcher, R., Kiger, C., "Enhanced and Miniaturized Wireless Valve Position Indicator Prototype for Nuclear Power Plants." American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Crane, Z., Kiger, C., "Minimizing Equipment Modifications Using EMI/RFI Mapping Techniques." 61st ISA Annual Power Industry Division (POWID) Symposium, Knoxville, TN (June 26–28, 2018).

Jackson, D.N., Woods, J.L., Kiger, C.J., "Evaluating Distributed Antenna Systems for Nuclear Power Plants." 61st ISA Annual Power Industry Division (POWID) Symposium, Knoxville, TN (June 26–28, 2018).

NATIONAL CONFERENCE PRESENTATIONS (cont.)

Lowe, C.L., Kiger, C.J., "Using a Cognitive Radio System to Support Wireless Technology Implementation at Nine Mile Point." 61st ISA Annual Power Industry Division (POWID) Symposium, Knoxville, TN (June 26–28, 2018).

Kiger, C.J. , Sexton, C.D., Hashemian, H.M., Toll, T.A., Dormann, L., Wasfy, W., "Avoiding Unnecessary Cable Replacement in Nuclear Power Plants." Proceedings of the American Nuclear Society Annual Meeting, Philadelphia, PA (June 17–21, 2018).

Shumaker, B.D., Hashemian, H.M., Kiger, C.J., Hashemian, A.H., "Management of Aging of Reactor Internal Components." Proceedings of the American Nuclear Society Annual Meeting, Philadelphia, PA (June 17–21, 2018).

Kiger, C.J., Hashemian, H.M., Sexton, C.D., Toll, T.A., "Research Gap in Management of Insulation Aging of Medium Voltage Cables in Nuclear Power Plants." Proceedings of the American Nuclear Society Annual Meeting, Philadelphia, PA (June 17–21, 2018).

Lowe, C.L., Kiger, C.J., Jackson, D.N., Young, D.M., "Implementation of Wireless Technologies in Nuclear Power Plants' Electromagnetic Environment Using Cognitive Radio System." 60th ISA Annual Power Industry Division (POWID) Symposium, Cleveland, OH (June 26–29, 2017).

Lowe, C.L., Kiger, C.J., Jackson, D.N., Woods, J.L., "Understanding Exclusion Zones of Modern Devices to Support Wireless Technology Implementation with Cognitive Radio System." 60th ISA Annual Power Industry Division (POWID) Symposium, Cleveland, OH (June 26–29, 2017).

Lowe, C.L., Kiger, C.J., Jackson, D.N., Young, D.M., "Implementation of Wireless Technologies in Nuclear Power Plants' Electromagnetic Environment Using Cognitive Radio System." American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).

Crane, Z., Kiger, C.K., "Electromagnetic Compatibility Qualification of Power Electronics for I&C Power Applications." American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).

Kiger, C.J., "International Activities to Develop Guidance on the Integration of Wireless Devices in Nuclear Power Plants." American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Kiger, C.J., Lowe, C.L., "Strategy for Implementation of Wireless Technologies in the Electromagnetic Environment of Nuclear Power Plants." American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Nace, D.M., Kiger, C.J., "Electromagnetic Compatibility Concerns of In-Situ Welding on Instrumentation and Control Systems." American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Kiger, C.J., Lowe, C.L., Dowdy, J.A., "Identifying Issues with Nuclear Instrumentation Systems Using Cable Testing Technologies." 57th ISA Annual Power Industry Division (POWID) Symposium, Scottsdale, AZ (June 2014).

NATIONAL CONFERENCE PRESENTATIONS (cont.)

Kiger, C.J., Headrick, B.J., Crane, Z.M., "Integrating Electromagnetic Compatibility (EMC) into the Design Modification Process: Example Application for Spent Fuel Pool Instrumentation." 57th ISA Annual Power Industry Division (POWID) Symposium, Scottsdale, AZ (June 2014).

Kiger, C.J., "Cable Aging Management and Monitoring Techniques." EQ Technical Meeting, Clearwater Beach, FL (November 12–15, 2013).

Kiger, C.J., "Wireless Technologies in Nuclear Facilities: Are EMC and Cyber Security Show-Stoppers." ANS 2013 Utility Working Conference and Vendor Technology Expo, Hollywood, FL (August 11–14, 2013).

Kiger, C.J., "Avoiding Heartaches during Qualification Testing by Designing Digital Systems with EMC in Mind." ANS 2013 Utility Working Conference and Vendor Technology Expo, Hollywood, FL (August 11–14, 2013).

Johnson, W.S., Kiger, C.J., "Wireless Monitoring of Tank Levels in Nuclear Reactor Containment." 56th ISA Annual Power Industry Division (POWID) Symposium, Orlando, FL (June 2013).

Kiger, C.J., "Evolution of Electromagnetic Environment Site Surveys to Support Plant Upgrades." 56th ISA Annual Power Industry Division (POWID) Symposium, Orlando, FL (June 2013).

Kiger, C.J., "EMC Considerations Beyond the Qualification Testing…Especially Grounding!" 2013 AMETEK Solidstate Controls Owners Conference, Columbus, OH (June 19–21, 2013).

Kiger, C.J., Moarefy, A., "Assessing the Vulnerability of Plant Equipment to Interference from Wireless Devices." 56th Annual ISA Power Industry Division (POWID) Symposium, Orlando, FL (June 2013).

Kiger, C.J., "Empowering the Nuclear Industry's Mobile Workforce: Are Exclusion Zones Enough?" 2013 ANS Annual Meeting, Atlanta, GA (June 16–20, 2013).

Johnson, W.S., Kiger, C.J., Hashemian, H.M., "Monitoring Tank Levels in Nuclear Reactor Containment." 13 ANS Annual Meeting, Atlanta, GA (June 16–20, 2013).

Kiger, C.J., "Electromagnetic Compatibility Concerns for Nuclear Power Plant Equipment; Addressing the Requirements." 2012 EQ Technical Meeting, San Antonio, TX (November 13–16, 2012).

Kiger, C.J., Johnson, W.S., Hashemian, H.M., Hudson, E., "Wireless Sensors for Condition Monitoring of Equipment within the Containment of Pressurized Water Reactors." 2012 ANS Winter Meeting and Nuclear Technology Expo, San Diego, CA (November 11–15, 2012).

Kiger, C.J., Shumaker, B.D., Johnson, W.S., Hashemian, H.M., "Expanding the Capabilities of Wireless Condition Monitoring Sensors into the Containment of Pressurized Water Reactors." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8–9, 2012).

Kiger, C.J., Shumaker, B.D., "Managing the Electromagnetic Compatibility and Wireless Coexistence Concerns for the Implementation of Existing and Future Wireless Technologies in Nuclear Power Plants." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8–9, 2012).

NATIONAL CONFERENCE PRESENTATIONS (cont.)

Kiger, C.J., Johnson, W.S., Hashemian, H.M., Hudson, E., "Wireless Sensors for Condition Monitoring of Equipment within the Containment of Pressurized Water Reactors." American Nuclear Society 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Diego, CA (July 22–26, 2012).

Kiger, C.J., "Addressing Electromagnetic Compatibility Concerns for Digital Upgrades." American Nuclear Society 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Diego, CA (July 22–26, 2012).

Hashemian, H.M., Kiger, C.J., O'Hagan, R.D., Riggsbee, E.T., Phipps, K.O., "Wireless Sensors for Equipment Health and Condition Monitoring in Nuclear Power Plants." 2nd Annual Future of Instrumentation International Workshop (FIIW), Oak Ridge National Laboratory, Oak Ridge, TN (November 2011).

Kiger, C.J., et al., "Introduction to Wireless Technology: A Perspective for the Power Generation Community." 54th ISA Annual Power Industry Division (POWID) Symposium, Charlotte, NC (June 2011).

Kiger, C.J., "EMC Overview: A Comparison of EPRI TR-102323 R1, R3, and NRC Regulatory Guide 1.180R1. How and When to Apply." AMETEK Solid State Controls Owners Conference, Columbus, OH (June 2011).

Kiger, C.J., et al., "Taking the 'Mag…ic' Out of Electromagnetic Compatibility." 54th Annual ISA Power Industry Division Symposium, Charlotte, NC, USA (June 2011).

Kiger, C.J., "Requirements and Test Methods for EMC Qualification Testing of Nuclear Power Plant Equipment to Support Digital Upgrades." 7th American Nuclear Society International Topical Meeting of Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies, Las Vegas, NV (November 2010).

Kiger, C.J., "The Emerging Role of Wireless Technologies in Nuclear Power Plants." 7th American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies, Las Vegas, NV (November 2010).

Kiger, C.J, et al., "Wireless Technology Applications in Nuclear Power Plants." Future of Instrumentation Workshop, Oak Ridge National Laboratory, Oak Ridge, TN (November 2009).

Hashemian, H.M., Kiger, C.J., Seibel, J.C., Shumaker, B.D., Feltus, M.A., "Wireless Technologies for Nuclear Facilities." Invited paper, 2009 Annual Meeting of American Nuclear Society, Atlanta, GA (June 14–18, 2009).

Kiger, C.J., Hashemian, H.M., Seibel, J.C., Wunderlich, R.J., Meininger, R.D., "Digital Upgrade Concerns and Considerations Regarding Electromagnetic Interference." 52nd Annual ISA Power Industry Division (POWID) Symposium, Chicago, IL (May 12–14, 2009).

Kiger, C.J., Hashemian, H.M., Seibel, J.C., "Wireless Sensors for Predictive Maintenance of Rotating Equipment in Industrial Environments." MARCON Conference, Knoxville, TN (May 5–7, 2009).

Kiger, C.J., Hashemian, H.M., Sexton, C.D., Meininger, R.D., Nace, D.M., "Electromagnetic Environment Testing to Support Digital Upgrades in Nuclear Power Plants." 6th American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Knoxville, TN (April 5–9, 2009).

NATIONAL CONFERENCE PRESENTATIONS (cont.)

Hashemian, H.M., Kiger, C.J., Morton, G.W., Shumaker, B.D., Carter, C., Feltus, M.A., "Wireless Sensor Applications in Nuclear Power Plants." 6th American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Knoxville, TN (April 5–9, 2009).

Hashemian, H.M., Hashemian, M., Kiger, C.J., Riggsbee, E.T., Seibel, J.C., Sexton, C.D., Linn, M., Manges, W., Kuruganti, T., Feltus, M.A., "Wireless Sensors for Predictive Maintenance of Rotating Equipment in Research Reactors." 6th American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface (NPIC & HMIT) Technologies, Knoxville, TN (April 5–9, 2009).

Hashemian, H.M., Shumaker, B.D., Morton, G.W., Kiger, C.J., "Wireless Sensors for Equipment and Process Condition Monitoring in Nuclear Power Plants." 51st ISA Annual Power Industry Division (POWID) Symposium, Scottsdale, AZ (June 2008).

Kiger, C.J., et al., "Physical Layer Simulation Study for the Coexistence of WLAN Standards." American Nuclear Society Conference, Albuquerque, NM (November 2006).

Kiger, C.J., et al., "Development of a Methodology for Indoor Propagation Simulation and Validation at 2.4GHz." International Instrumentation Symposium of ISA, Knoxville, TN (May 2005).

Publications

INDUSTRY REPORTS

Hashemian, H.M., et al., "Implementation Guidelines for Wireless Networks and Wireless Equipment Condition Monitoring." EPRI Final Report, 1019186 (November 2009).

Howlader, M., Kiger, C.J., Ewing, P.D., "Coexistence Assessment of Industrial Wireless Protocols in the Nuclear Facility Environment." U.S. Nuclear Regulatory Commission Report NUREG/CR-6939 (July 2007).

JOURNAL & MAGAZINE ARTICLES

Hashemian, H.M., Kiger, C.J., "Wireless Data Communication in NPP." *Nuclear Plant Journal,* Vol. 37 No. 2 (March–April 2019).

Hashemian, H.M., Kiger, C.J., Sexton, C.D., O'Hagan, R.D., Dormann, L., Wasfy, W., "Implementation of New Cable Condition-Monitoring Technology at Oyster Creek Nuclear Generating Station." *Nuclear Technology,* Vol. 200, No. 2 (October 2017).

Kiger, C.J., Hashemian, H.M., Moarefy, A., "Wireless Technology." *Nuclear Plant Journal,* Vol. 33, No. 2 (March–April 2015).

Kiger, C.J, Johnson, S.W., Hashemian, H.M, Hudson, E.K., "Harnessing Wireless Data from the Containment of Nuclear Power Plant." *IEEE Instrumentation & Measurement Magazine* (October 2013).

Kiger, C.J., "Empowering the Nuclear Industry's Mobile Workforce: Are Exclusion Zones Enough?" *ANS Transactions* (June 2013).

Johnson, W.S., Kiger, C.J., Hashemian, H.M., "Monitoring Tank Levels in Nuclear Reactor Containment." *ANS Transactions* (June 2013).

JOURNAL & MAGAZINE ARTICLES (cont.)

Hashemian, H.M., Kiger, C.J., Morton, G.W., Shumaker, B.D., "Wireless Sensor Applications in Nuclear Power Plants." *Nuclear Technology,* Vol. 173, No. 1 (January 2011).

Hashemian, H.M., Kiger, C.J., Seibel, J.C., Wunderlich, R.W., Meininger, R.D., "Concerns About Electromagnetic Interference in Nuclear Plants Related to Digital Upgrades." *Power Magazine,* Vol. 154, No. 2 (February 2010).

Hashemian, H.M., Morton, G.W., Shumaker, B.D., Kiger, C.J., "Nuclear Power Comeback Sure to Employ Wireless Tools." *InTech Magazine,* an ISA publication (January 2009).