Assessing of Wireless Communication Technologies

Advanced Sensors and Instrumentation Annual Webinar
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Project Overview

• Goals and Objectives
  – Assessment of wireless communication technologies and their applications in nuclear environment to support development of a technology demonstration test plan
  – Advance the implementation of “smart” processes and structures to enable the ability to cost effectively create a large network of sensors and better data analytics for operational decisions
  – Develop three-tier sensing and communication strategy
    1. In-core: data signal from in-core to outside the pressure vessel
    2. Containment building: data from containment building to balance of plant network
    3. Balance of the plant network: transmit to the data cloud and control room.

• Participants (2020)
  – INL: Vivek Agarwal, James A. Smith, and Koushik A. Manjunatha
  – North Carolina State University: Cheryl Xu
  – Michigan State University: Yiming Deng

• Schedule
  – Milestone report completed, August 2020, “Wireless Sensing and Communication Capabilities from In-Core to a Monitoring Center”
Accomplishments

• Sensing Communication Infrastructure
  – Developed a three-tier strategy for wireless transmission of measurements to a monitoring center or the cloud

Tier 1: In-core and Containment Sensors

*Typical Multi-layer
- Gas tight shell
- Projectile shield

Pressurized pipeline setup with a harmonic RF sensor tag

Voltage of a Polymer Derived Ceramic (PDC) sensor as a function of temperature.

In-Core: High Temperature PDC Sensor (>1000 °C)
Accomplishments II

- **Tier 2: Containment Area Interrogator**
  - Sensors located in-core and containment area
  - Energize RF sensors and receive sensor signals
  - Process the signals and extract precise measurements
  - Transmit to balance of plant

- **Tier 3: Balance of Plant Network**

- **Documentation and Participation**
  - James A. Smith “Using a RFID Sensor as a Voltage Control Oscillator,” provisional patent no. 62/926,820
  - Participated on the IEEE working committee for IEEE 21451-7-2011 --Smart transducer interface for sensors
  - Milestone report
Technology Impact

- **Advances the state of the art for nuclear application**
  - Developed a three-tier strategy to obtain in-core measurements and wirelessly transmit to a data center
  - Technology maturity (TRL) varies between tiers
- **Supports the DOE-NE research mission**
  - Wireless sensors and data transmission will enable nuclear plants to compete
- **Impacts on the nuclear industry**
  - Reduce costs
    - Laying new cabling in nuclear plants is ≈$2,000 per foot in 2009 [1]
    - Industrial wireless expenses expected to drop from $20/foot to $2/foot in 2010 [2]
  - Increase productivity and plant efficiency
    - Reduce manual measurements
    - Make measurements in critical new areas such as the core
    - Have the confidence to operate with lower margins
    - Provide more effective data analytics for operational decisions
- **Commercialization**
  - License technology to power plant vendors or instrumentation suppliers

Conclusion

• Designed an in-core wireless sensing and communication system
  – Passively powered ceramic high-temperature sensors that are wireless
  – Provide real-time sensing in-core and within the containment structure
  – Capable of multi-sensing of temperature, pressure, strain, etc.
  – Integrated into a communication network for delivery to a processing center

• Identified two areas for additional wireless development
  – Transmission through the containment structure
  – Pressure vessel wall

• Provided intellectual property
  – James A. Smith “Using a RFID Sensor as a Voltage Control Oscillator,” provisional patent no. 62/926,820 and full patent application
  – Milestone Report: “Wireless Sensing and Communication Capabilities from In-Core to a Monitoring Center”

• Advanced technology that enables
  – Reduced costs
  – Increase productivity, plant efficiency, wide-ranging data analytics for operational decisions

• Questions
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