Transmission of Information by Acoustic Communication along Metal Pathways in Nuclear Facilities

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Goal - Develop and demonstrate methods for transmission of information in nuclear facilities by acoustic means along existing in-place metal piping infrastructure

- Develop and demonstrate the ability to transmit greater amounts of data and other signals through physical boundaries in nuclear facilities
- Address new communication demands needed for advanced measurement and control technologies including protection of data.
- Take into consideration the environment and the conditions under regular operation and/or accident scenario.
- Test and validate prototype through demonstration in appropriate representative environment.

Participants
- Argonne National Laboratory
- University of Illinois Urbana-Champaign

Schedule
- Three-year project, Year 1 just completed
Seek innovative means to transmit information that overcomes physical hurdles that beset conventional communication methods, i.e. both wired and radio frequency wireless.

- Establishing a wireless RF system at a nuclear facility requires careful positioning of transmitters and receivers that take into account the plant topology.
- In case of a disruptive event, such as a major natural disaster or accident, wireless sensors are likely to be perturbed.
- Post-accident water sprays can strongly scatter free-space RF waves.
- Pipes are omnipresent in a nuclear facility.
- Adopt pipes and other metal structures as conduits for signals launched as guided acoustic surface waves.
Background

Challenge

- Because of harsh environment (mostly high temperature of up to 350°C of the process fluid pipes), ultrasonic transducers developed and demonstrated in prior studies on acoustic wave communications might not be suitable for deployment in communication system developed for nuclear reactor.

Mitigation

- Prior experience of developing temperature-resilient contactless electromagnetic acoustic transducers (EMAT)
- Explore the use of EMAT in developing acoustic communication system for nuclear reactor applications.
- Survey low-temperature process piping inside containment
Accomplishments

- Surveyed NPP process piping for good acoustic candidate
  - Selected through-containment as a challenge problem
  - Identified CVCS piping as good candidate – Relatively low temperature
  - Setup experiment benchtop to replicate material and geometry

Representative through-containment piping
Accomplishments

Task 1.1 - Identify and test ultrasonic transducers and amplifiers for coupling into, transmission along, and reception out of pipe infrastructure.

- Setup benchtop scale experiment facility – Replicates through-containment CVCS piping
Accomplishments

- Task 1.1 - Identify and test ultrasonic transducers and amplifiers for coupling into, transmission along, and reception out of pipe infrastructure.
  - Experimentally investigated different communication modulation schemes

[Graphs showing ASK and PSK modulation with 50 ms bit pulse duration]
Task 1.2 - Derive performance specifications for individual transducers, amplifiers, and couplers

- Performed COMSOL multi-physics simulations

Response signals due to axial SH wave mode
Technology Impact

-Nuclear Energy

-Developing information channel for through-barrier communication
  - Solves weak link in wireless communications – RF attenuates significantly in concrete

-Developing a diverse means of communication for use during accidents
  - Solves weak link in wireless communications – Disrupted geometric orientations, high humidity, high temperature
Conclusion

- In-containment CVCS piping was identified as a good candidate for acoustic communications medium.
- Identified through experimental activities to date a number of parameters that could affect the transmission of signals over long distances.
- Based on preliminary results of signal transmission, OOK looks like the preferred modulation scheme for information transmission.
- Partnered with a commercial partner for Year 3 tests in a nuclear facility.